**Vehicle Environmental Engineering**
**Ford Motor Company**

**1500 Enterprise Drive**
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September 19, 2011

Ms. Annette Hebert, Chief
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Haagen-Smit Laboratory
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El Monte, California 91734-8001

Dear Ms. Hebert

Subject: 2013 MY LDV and LDT Application for Certification: Common Section Initial Submission

This submittal contains the CBI and FOI versions of the Initial 2013 MY Common Section for your review and approval. This submittal follows the CAP 2000 Guidance – recommended Part-1 Application format, based on the Part-1 application requirements found in 40CFR86.1844-01(d).

Sections included:

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| 03.00.00.00 | Evaporative / Refueling Family Description |
| 04.00.00.00 | Description of Durability Method |
| 09.00.00.00 | OBD Description |
| 12.00.00.00 | Description of Vehicles Covered by Certificate & Test Parameters |
| 14.00.00.00 | Request for Certification |
| 15.00.00.00 | Other Information |
| 16.00.00.00 | Confidential Information |
| 17.00.00.00 | California ARB Information |
| | |

The subject document contains confidential information (Section 16) for which Ford requests confidential treatment. In the event you believe that all or part of that submitted information may not be entitled to confidential treatment, Ford asks that you provide reasonable notice of not less than ten working days prior to any contemplated disclosure. Please direct all notices to, Alan Prescott, (A.D.), Office of the General Counsel, Ford Motor Company, Room 437-A1, World Headquarters, One American Road, Dearborn, MI 48126-2798; telephone (313) 390-5621, E-mail; APRESCOT@ford.com

If you have any questions, with regard to this submittal, please contact Mr. Travis Henney at thenney@ford.com or (313) 399-7256.

Sincerely,

Todd Fagerman

Todd M. Fagerman, Manager
Car & Truck Certification
Vehicle Environmental Engineering

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# FORD MOTOR COMPANY
# 2013 MY APPLICATION FOR EMISSION CERTIFICATION

## 01.00.00.00 CORRESPONDENCE and COMMUNICATIONS

### *01.01.00.00* Mailing Information

### *01.01.01.00* Cognizant Technical Representative

Listed below are the name, address and telephone number of Robert D. Brown, the Ford Motor Company cognizant technical representative. Also listed is contact information for Todd M. Fagerman and Peter D. Souchock. At the time of publication, please provide guidance documents and other technical information to those individuals. Non-OBD information exchanges related to emissions certification (e.g., Executive Orders and/or Certificates of Conformity) should be directed to Todd M. Fagerman. Information exchanges related to OBD should be addressed to Peter D. Souchock.

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*01.04.00.00* On Site Certification Engineering Observer at EPA

To ensure that Ford Motor Company certification vehicles are processed through the EPA Laboratory in a manner consistent with established test schedules and procedures, a Certification Engineering representative has been assigned from the Certification Engineering Department. Additional Ford Motor Company personnel, not otherwise specified in this Application, may be on site to provide assistance to the vehicle Certification Engineering representative in the performance of his duties.

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# ORVR System Description

**ORVR Fuel System Components:** Figure 1 illustrates a generic Ford ORVR-equipped fuel system. The generic ORVR-equipped fuel system utilizes the following hardware:

- Specially Designed Filler Pipe - Ensures the formation of a dynamic liquid seal during vehicle refueling. The pipe may also come equipped with a vapor recirculation line to minimize vapor growth during refueling.
- Specially Designed Fill Control Valve - Limits fuel levels in the fuel tank and allows refueling vapors to travel through the valve into the vapor line. Some fill control valves act to separate entrained liquid fuel from fuel vapors passing through the valve.
- Vapor Recirculation Line - Routes a portion of refueling vapors to the top of the fuel filler pipe to limit amount of relatively fresh air being entrained by action of liquid seal. A fixed or variable size orifice controls the flow of recirculated vapors.
- Anti-spitback Device - Located in line with the fuel filler pipe, this device (usually a flapper door valve or fill tube check valve with a piston/spring/valve seat design) impedes spitback of liquid at the end of the refueling event.
- Carbon Canister - Used to store refueling vapors for use later in engine operation. Ford uses an integrated system to capture both evaporative and refueling emissions on all programs except plug-in hybrids. On plug-in hybrids, Ford utilizes a non-integrated system which utilizes the canister for refueling emissions and a pressurized fuel tank for evaporative emissions.
- Carbon Canister Vent Valve – Systems are equipped with a solenoid that is normally open to allow fresh air to enter and exit the canisters as required by system performance. This valve closes to seal the system for the diagnostic system leak check. Hybrid programs utilize an Electronic Leak Check Module (ELCM) to conduct leak detection by monitoring flow through an orifice.

All fuel system designs, including those equipped to control refueling emissions, contain safety features required to ensure compliance with rollover and crash safety requirements.

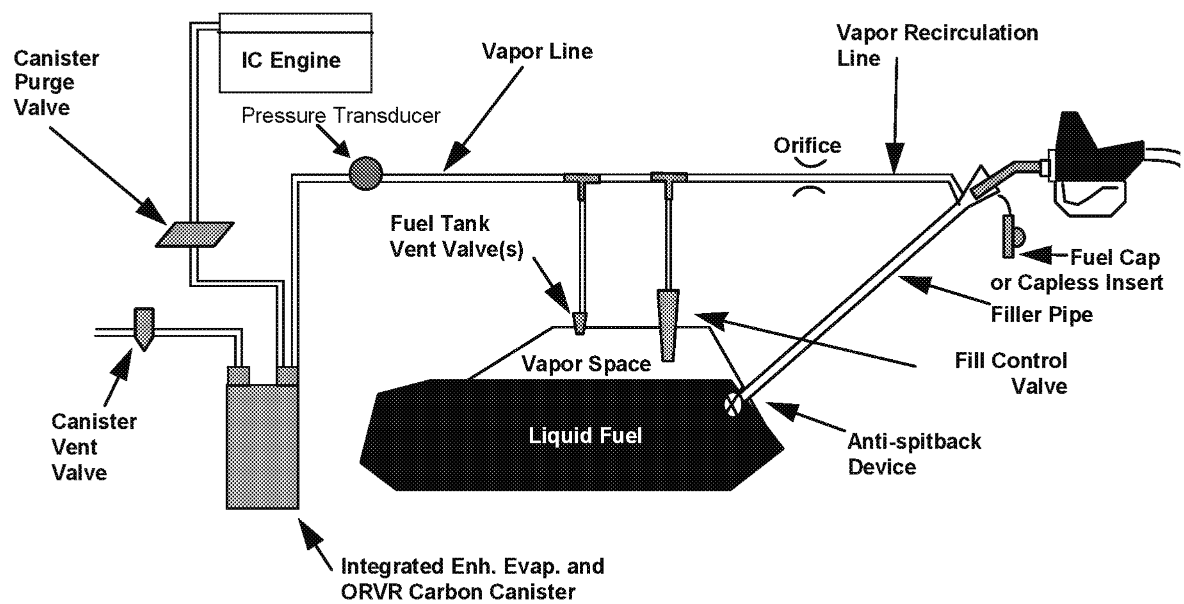



**Figure 1. Generic ORVR-Equipped Ford Fuel System**

# ORVR System Description

**Operation of ORVR System During Refueling:** During refueling, the ORVR fuel system routes the majority of refueling vapors to a carbon canister, where they are adsorbed and stored for later use. A recirculation line guides a small portion of refueling vapors to the top of the fuel neck to displace relatively fresh air which otherwise would be drawn into the fuel tank by the action of the fuel flowing through the filler pipe. A fixed or variable diameter orifice located in the recirculation line restricts the quantity of fuel vapors being recirculated to ensure no vapors spill out the fuel filler inlet into the atmosphere.

Other vapor routes are blocked during vehicle refueling. A closed vapor management valve blocks vapors from traveling to the engine. A dynamic liquid seal constitutes the primary mechanism for blocking refueling vapors from escaping out the fuel filler pipe. The shape of the fuel filler pipe rapidly constricts shortly after the site of maximum fuel nozzle penetration. This constriction causes the fuel to flow in a manner such that no fuel vapors can escape to the atmosphere from the fuel tank through the fuel filler neck. Instead, the action of the incoming fuel draws fresh air (and recirculated vapor, where applicable) into the filler neck. Once refueling stops and the liquid seal is broken, an anti-spitback device -- such as a fill tube check valve -- acts to restrict fuel spitback and wellback.

Refueling shut off occurs due to a float rising in the fuel limiting vent valve. As the float rises, the valve closes the vapor pathway to the vapor lines. Pressure in the fuel tank builds, in turn, producing a pressure pulse that travels up the fuel filler neck. The pressure pulse in the filler neck causes liquid fuel to cover the shut-off port on the fuel-dispensing nozzle, thereby causing the nozzle to shut off.

**Fuel Filler Inlet Design:** Ford fuel filler inlets conform to California fuel filler inlet requirements, which in their geometric specifications are almost identical to ISO 9158 and SAE J285. Ford fuel inlets also employ a fuel nozzle restrictor conforming to the requirements of 40 CFR §80.24. Ford has elected to discontinue the use of a metallic flapper valve on the fuel filler inlet restriction. The restriction hole of the newly designed nozzle inlet plate in the fuel pipe is strategically sized and located such that when the fuel nozzle is introduced in the fuel pipe to dispense fuel, it helps ensure the fuel nozzle contacts the fill pipe plate for grounding, bonding.

# TYPICAL EVAPORATIVE EMISSION SYSTEM

## DESCRIPTION OF EVAPORATIVE EMISSION CONTROL SYSTEM

The Evaporative Emission Control System consists of a sealed fuel tank assembly, a filler pipe, a fuel cap or capless insert, fuel tank vapor orifice(s) (fuel limiting vent valves and grade vent valves), materials that adsorb fuel vapors (such as carbon in a canister), and a canister purge valve.

## DESCRIPTION OF CANISTER PURGE

The carbon canister is purged of fuel vapor during normal vehicle driving. The flow of fuel vapor to the engine is controlled by the canister purge valve. The canister purge valve is electronically actuated by the Powertrain Control Module (PCM).

# EVAPORATIVE EMISSION COMPONENTS

## TYPICAL CANISTER PURGE VALVE

The typical canister purge valve is used to control the purge of stored fuel vapor inside the carbon canister assembly. The canister purge valve is electronically controlled by the Powertrain Control Module (PCM). The canister purge valve is a normally closed valve. When the PCM actuates the canister purge valve, the engine vacuum is applied to the carbon canister(s), and the desorbed fuel vapor is drawn through the canister purge valve and into the engine for consumption.

## TYPICAL CARBON CANISTER

The carbon canister contains activated carbon for the storage of fuel vapor. The carbon canister is purged of the stored fuel vapor by the operation of the canister purge valve.

Some vehicles may include an engine buffer canister, which also contains activated carbon for the storage of fuel vapor. The engine buffer canister is commonly located in series with the canister purge valve or integrated into the primary canister. The function of the engine buffer canister is not to control evaporative emissions; rather, it buffers the engine from high concentrations of fuel vapor during vehicle operation in order to prevent undesired air/fuel ratio fluctuations. As such, engine buffer canisters need not be loaded with butane/nitrogen mixtures prior to exhaust or evaporative emissions testing.

## TYPICAL VAPOR BLOCKING VALVE (NON PLUG-IN HYBRID)

The typical vapor blocking valve (VBV) is used to control the purge of stored fuel vapor inside the fuel tank assembly. The VBV is electronically controlled by the Powertrain Control Module (PCM). The VBV is a normally open valve. When the PCM actuates the VBV, the valve closes and the application of engine vacuum to the fuel tank's vapor dome is prevented.

## TYPICAL FUEL TANK ISOLATION VALVE (PLUG-IN HYBRID ONLY)

The typical fuel tank isolation valve is used to close the NIRCOS (Non-Integrated Refueling Canister Only System) pressurized fuel tank in order to contain evaporative emissions. The FTIV is electronically controlled by the Powertrain Control Module (PCM). The fuel tank isolation valve is a normally closed valve. When the PCM actuates the FTIV, the valve opens in order to vent the fuel tank through the carbon canister to enable refueling.

## TYPICAL AIR INDUCTION SYSTEM (AIS) HYDROCARBON (HC) ADSORBER

Some vehicles may include an HC adsorber located in the engine AIS to capture fuel vapor from the intake manifold or crankcase after engine shutdown. The adsorber may contain activated carbon or other adsorptive material. This component is continuously purged during engine operation. In compliance with CARB's MAC 2001-03, and since the CFR only requires preconditioning of evaporative emission canisters, AIS HC adsorbers need not be preconditioned prior to testing.

## TYPICAL FUEL LIMITING VENT VALVE (FLVV)

The FLVV is a three piece assembly consisting of the vent tube, vapor seal (which has an o-ring on both ends for leak protection), and the "check valve" which consists of a float with a spring assembly. The fuel limiting vent valve assembly provides two functions: (1) Limits fuel tank fill volume to the required refill volume, (2) roll-over protect the vent tube path for crash. The valve during normal vehicle driving is in an upright position.

During a roll-over condition, the FLVV spring closes the float to the vent tube to prevent liquid fuel from entering the vent.

## TYPICAL GRADE VENT VALVE (GVV)

The grade vent valves (GVV) are typically mounted on the front and the rear top of the fuel tank. They are designed to prevent liquid from the fuel tank from entering the vapor stream, while allowing the fuel vapor to move through the evaporative emission control system.

The spring and float within each valve shuts off the vapor stream whenever liquid gasoline reaches the inlet port. The GVV reopens when the attitude of the fuel tank returns to horizontal and the liquid fuel drains from the area of the GVV. In the vertical position the open bottom float will lift and close. In the rolled over position the spring will push the float closed whenever the roll over angle permits liquid gasoline to reach the float. In the upside down position the weight of the float and the spring force will close the vapor path.

## TYPICAL FILLER PIPE

The filler pipe assembly transfers liquid fuel from the fuel nozzle to the tank and has a "liquid seal" design. On some ORVR vehicles, a recirculation line connects from the main vapor line and supplies vapor from the tank to the top of the filler pipe to minimize the amount of fresh air that is drawn into the pipe.

At the top of the filler pipe, a fuel cap is installed, which seals the fuel tank assembly. The fuel cap includes a vacuum relief valve. Some vehicles also include pressure relief in the fuel cap. On some vehicles, Ford utilizes a capless refueling system which seals the fuel tank without use of a fuel cap. Like the fuel cap, the capless refueling system includes vacuum relief capability.

# ALTERNATE DURABILITY PROTOCOL

## I Applicability

The following description is applicable to 2013 and subsequent model year passenger cars and trucks.

## II REPORTING EQUIVALENCY FACTORS

For 2013 durability groups that carryover from previous model year durability programs that used the Ford High Speed Cycle (HSC or FAMA – Fast Approved Mileage Accumulation) equivalency factors are reported on a durability group basis.

Please see section 04.00.00.01 for equivalency factors.

## III CALCULATION OF THE EQUIVALENCY FACTOR

Equivalency Factors are calculated according to 40 CFR § 86.1823-08 by collecting catalyst temperatures on both Ford's High Speed Cycle (HSC or FAMA – Fast Approved Mileage Accumulation) and the Ford modified length version (to fit Ford service track) of the EPA SRC cycle as allowed by Appendix V-(2.) of Part 86. Please see Figures 1 & 2, below. Ford uses a 5-mile track for service accumulation; accordingly the lap references in the SRC description below use the 5-mile lap. Alternatively, catalyst temperature cycles for equivalency factor determination may be collected on a chassis dynamometer.

For new, non-carryover, 2010 durability groups that use the EPA SRC cycle for durability, equivalency factors are not applicable and are not calculated. The EPA SRC cycle used for durability was modified the length of the lap segment of the SRC to be 2.5 miles, such that it is able to be run on our 5 mile track. Therefore, two lap segments of the SRC are completed each for 5 mile circuit of Ford's track.

Equivalency factors are calculated using the following steps:

***Step 1: Record the temperature histogram on the customized/alternative Road Cycle.***

***Step 2: Calculate the bench aging time for the bench aging cycle using EPA's BAT calculator (40 CFR § 86.1823-08(d)(3)) and the customized/alternative road cycle (FAMA) temperature histogram.***

***Step 3: Record the temperature histogram on EPA's SRC.***

***Step 4: Calculate the bench aging time for the bench aging cycle using EPA's BAT calculator (40 CFR § 86.1823-08(d)(3)) and the SRC temperature histogram.***

***Step 5: Calculate the equivalency factor which equates the customized/alternative road cycle bench aging time divided by the SRC bench aging time*** – The following presents that calculation.

Equivalency Factor (EF) = Alternative road cycle aging time/SRC aging time

It is the intention of bench aging process to replicate road based catalyst deterioration experienced on the FAMA cycle by emissions matching and catalyst midbed time-at-temperature data obtained from catalysts and oxygen sensors. Aging cycle targets from accelerated fleet data are determined by calculating the hours necessary to achieve deterioration that reproduces full (or intermediate) useful life fleet average HC and NOx emissions for any engine/catalyst/HEGO system. Other considerations include catalyst inefficiency changes and fleet average deterioration rates (DFs).

One can replicate the Ford durability process by running the publicly available Ford FAMA drive cycle over the full useful life of a vehicle.

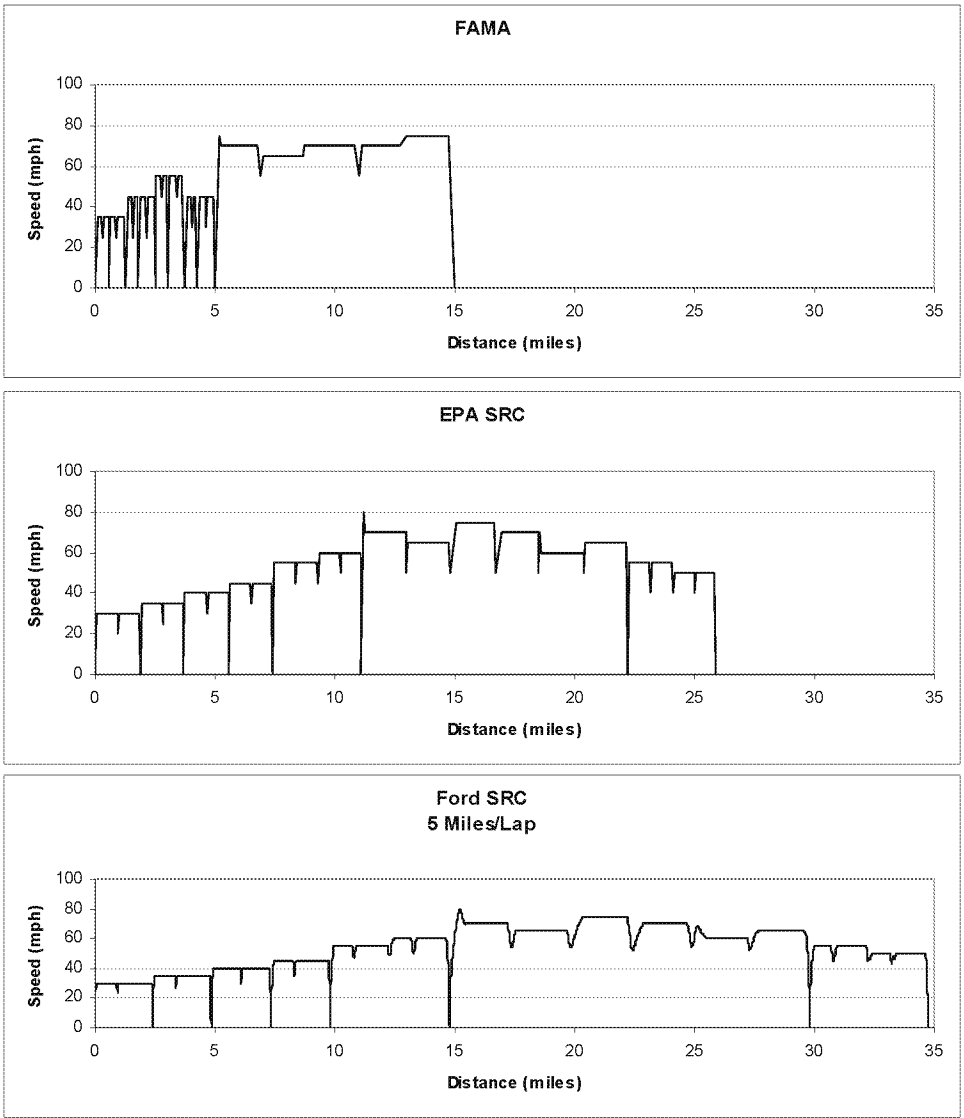



Figure 1 - Speed/Distance Comparison of Drive Cycles

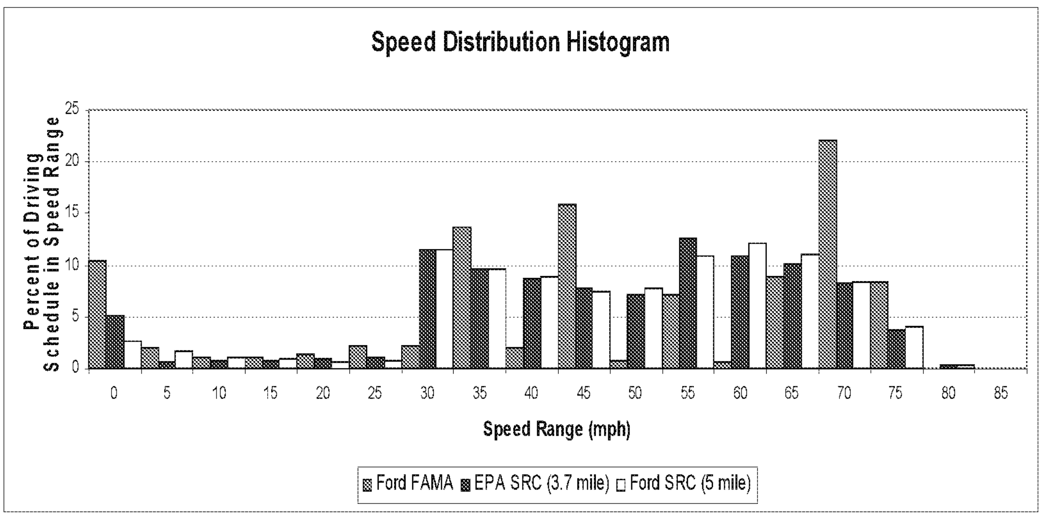



Figure 2 - Speed Histograms of Drive Cycles

CAP 2000 DURABILITY GROUPING DIVISIONS -- 2013 Model Year

| Test Group | | Program | Standard | Equivalency Factor* |
|---|---|---|---|---|
| **PD-RH -- DURABILITY GROUPS** | | | | |
| PD-RH -- DURABILITY GROUP 1 (4.0 - 3.0) | | | | |
| DURABILITY GROUP DFMXGPGNND1B | | | | 1.0 |
| DFMXJ03.7VHJ | 3.7L | MKT Limo/Hearse | T2B8(LEV2) | |
| PD-RH -- DURABILITY GROUP 2 (2.9 - 2.2) | | | | |
| DURABILITY GROUP DFMXGPGNND2A | | | | 1.0 |
| DFMXV02.0VZ2 | 2.0 | Focus | T2B3(SULEV2) | |
| PD-RH -- DURABILITY GROUP 4 (1.5 - 1.1) | | | | |
| DURABILITY GROUP DFMXGPGNND4B | | | | 1.0 |
| DFMXV01.6VDB | 1.6L | Fiesta | T2B4(ULEV2q) | |
| DURABILITY GROUP DFMXGPGNND4C | | | | 1.0 |
| DFMXV05.8VE2 | 5.8L | Mustang Shelby | T2B5(LEV2) | |
| DURABILITY GROUP DFMXGPGNND4D | | | | 1.7 |
| DFMXT02.01DW | 2.0 | Transit Connect | T2B4(ULEV2q) | |
| PD-RH -- DURABILITY GROUP 5 (1.0 - 0.8) | | | | |
| DURABILITY GROUP DFMXGPGNND5A | | | | 2.3 |
| DFMXT06.24D2 | 6.2L | F-150 SVT Raptor/Harley | T2B4(ULEV2q) | |
| DURABILITY GROUP DFMXGPGNND5B | | | | 1.0 |
| DFMXV05.0VD5 | 5.0L | Mustang | T2B4(ULEV2q) | |
| | | ADP Vehicle | T2B4(LEV2) | |
| DURABILITY GROUP DFMXGPGNND5C | | | | 1.0 |
| DFMXV03.7VDT | 3.7L | Mustang | T2B4(ULEV2q) | |
| DURABILITY GROUP DFMXGPGNND5D | | | | 1.0 |
| DFMXV02.5VEX | 2.5L | Fusion | T2B5(ULEV2) | |
| DURABILITY GROUP DFMXGPGNND5E | | | | 1.0 |
| DFMXT02.52ET | 2.5L | Escape | T2B5(ULEV2) | |
| DURABILITY GROUP DFMXGPGNND5G | | | | 2.5 |
| DFMXT06.85HT | 6.8L | Econoline | T2B8(ULEV2q) | |
| PD-RH -- DURABILITY GROUP 6 (0.7 - 0.5) | | | | |
| DURABILITY GROUP DFMXGPGNND6A | | | | 1.0 |
| DFMXT03.72EE | 3.7L | Edge/MKX | T2B5(ULEV2) | |
| PD-RH -- DURABILITY GROUP 7 (3.4 - 2.6) Direct Injection | | | | |
| DURABILITY GROUP DFMXGPGNND7A | | | | 1.0 |
| DFMXV01.6VZF | 1.6 | Fusion GTDI PZEV | T2B3(SULEV2) | |
| PD-RH -- DURABILITY GROUP 8 (1.7 - 1.3) Direct Injection | | | | |
| DURABILITY GROUP DFMXGPGNND8A | | | | 1.0 |
| DFMXV02.0VE6 | 2.0L | MKT Livery GTDI | T2B5(ULEV2) | |
| DURABILITY GROUP DFMXGPGNND8B | | | | 1.0 |
| DFMXT02.02EC | 2.0L | Explorer/Edge/MKX GTDI | T2B5(ULEV2) | |
| DURABILITY GROUP DFMXGPGNND8D | | | | 1.0 |
| DFMXV02.0VEY | 2.0L | Fusion/MKZ GTDI | T2B5(ULEV2) | |
| DURABILITY GROUP DFMXGPGNND8E | | | | 1.0 |
| DFMXT02.02E1 | 2.0L | Escape GTDI | T2B5(ULEV2) | |
| DURABILITY GROUP DFMXGPGNND8F | | | | 1.0 |
| DFMXT03.53E2 | 3.5L | Explorer/Explorer Police GTDI | T2B5(ULEV2) | |
| DURABILITY GROUP DFMXGPGNND8G | | | | 1.0 |
| DFMXV03.5VEP | 3.5 | Taurus/MKS/Flex/MKT | T2B5(ULEV2) | |
| DURABILITY GROUP DFMXGPGNND8H | | | | 1.0 |
| DFMXT01.62E9 | 1.6L | Escape T2B4 GTDI | T2B4(ULEV2q) | |
| DFMXV01.6VDF | 1.6L | Fusion GTDI | T2B4(ULEV2q) | |
| | | ADP Vehicle | T2B4(ULEV2q) | |
| DURABILITY GROUP DFMXGPGNND8I | | | | 1.0 |
| DFMXT02.02EX | 2.0L | Explorer/Edge/MKX GTDI | T2B5(ULEV2) | |
| DFMXT02.02EX | 2.0L | Explorer/Edge/MKX GTDI | T2B5(ULEV2) | |
| | | ADP Vehicle | T2B5(ULEV2) | |

| CAP 2000 DURABILITY GROUPING DIVISIONS -- 2013 Model Year Test Group | | Program | Standard | Equivalency Factor* | |
|---|---|---|---|---|---|
| PD-RH -- DURABILITY GROUP 9 (1.2 - 0.9) Direct Injection | | | | | |
| DURABILITY GROUP DFMXGPGNND9A | | | | 1.0 | |
| DFMXV02.0VER | 2.0 | Focus ST GTDI | T2B4(ULEV2q) | | |
| DURABILITY GROUP DFMXGPGNND9B | | | | | |
| DFMXT03.54DX | 3.5L | F150 | T2B4(ULEV2q) | 1.0 | |
| **FFV PD-RH -- DURABILITY GROUPS** | | | | | |
| FFV PD-RH -- DURABILITY GROUP 1 (2.0-1.5) | | | | | |
| DURABILITY GROUP DFMXGPGEND1A | | | | 2.0 | |
| DFMXT05.44BC | 5.4L 3V | Expedition/Navigator FFV | T2B4(ULEV2q) | | |
| DFMXT05.45BR | 5.4L 3V | Expedition/Navigator LIMO FFV | T2B8(ULEV2q) | | |
| | | ADP Vehicle | T2B8(ULEV2q) | | |
| FFV PD-RH -- DURABILITY GROUP 2 (1.4-1.0) | | | | | |
| DURABILITY GROUP DFMXGPGEND2A | | | | 1.0 | |
| DURABILITY GROUP DFMXGPGEND2B | | | | 2.3 | |
| DFMXT04.65H9 | 4.6L 2V | Econoline FFV | T2B8(ULEV2q) | | |
| DURABILITY GROUP DFMXGPGEND2C | | | | 2.3 | |
| DFMXT05.45HK | 5.4L 2V | Econoline FFV | T2B8(ULEV2q) | | |
| DFMXT05.45HL | 5.4L 2V | Econoline Ambulance | T2B8(ULEV2q) | | |
| | | ADP Vehicle | T2B8(ULEV2q) | | |
| DURABILITY GROUP DFMXGPGEND2E | | | | 1.0 | |
| CFMXT05.03D7 | 5.0L | F150 FFV | T2B4(ULEV2q) | | 1 |
| FFV PD-RH -- DURABILITY GROUP 3 (0.9-0.7) | | | | | |
| DURABILITY GROUP DFMXGPGEND3A | | | | 1.0 | |
| DFMXT06.27HL | 6.2L | F-Series Super Duty FFV | T2B8(ULEV2q) | | |
| FFV PD-RH -- DURABILITY GROUP 4 (0.6-0.4) | | | | | |
| DURABILITY GROUP DFMXGPGEND4A | | | | 2.3 | |
| DFMXT05.44HY | 5.4L 3V | Expedition/Navigator FFV | T2B8 | | |
| DURABILITY GROUP DFMXGPGEND4B | | | | 1.0 | |
| DFMXV03.7VE8 | 3.7L | MKS/MKZ/MKT Livery | T2B5(ULEV2) | | |
| DFMXT03.53E8 | 3.5L | Explorer | T2B5(ULEV2) | | |
| DFMXV03.5VEA | 3.5L | Taurus Police FFV | T2B5(ULEV2) | | |
| DFMXT03.73DM | 3.7L | Explorer/Explorer Police FFV | T2B5(ULEV2) | | |
| | | ADP Vehicle | T2B5(ULEV2) | | |
| DURABILITY GROUP DFMXGPGEND4C | | | | 1.0 | |
| DFMXV02.0VD2 | 2.0 | Focus FFV | T2B4(ULEV2q) | | |
| DURABILITY GROUP DFMXGPGEND4D | | | | 1.0 | |
| DFMXV02.0VE3 | 2.0 | Focus FFV | T2B5(ULEV) | | |
| **HEV PD-RH -- DURABILITY GROUPS** | | | | | |
| HEV PD-RH -- DURABILITY GROUP 1 (4.8-3.6) | | | | | |
| DURABILITY GROUP DFMXHHGNND1A | | | | 1.0 | |
| DFMXV02.0VZL | 2.0L | Fusion/C-Max FHEV | T2B3(SULEV2) | | |
| DURABILITY GROUP DFMXHHGNND1B | | | | 1.0 | |
| DFMXV02.0VZP | 2.0L | Fusion/C-Max PHEV | T2B3(SULEV2) | | |
| **DIESEL PT-PD -- DURABILITY GROUPS** | | | | | |
| DIESEL PT-PD -- DURABILITY GROUP 1 (3.0-2.3) | | | | | |
| DURABILITY GROUP DFMXDPDNNF1A | | | | 1.0 | |
| DFMXD06.771C | 6.7L | F-Series Super Duty >10K Diesel | chHDDsFIN-(0.4)/ULEV2 | | |
| | | DF Vehicle | chHDDsFIN-(0.4)/ULEV2 | | |

| CAP 2000 DURABILITY GROUPING DIVISIONS -- 2013 Model Year | | | Standard | Equivalency Factor* |
|---|---|---|---|---|
| **Test Group** | | **Program** | | |
| DURABILITY GROUP DFMXDPDNNF1B | | | | 1.0 |
| DFMXD06.761A | 6.7L | F-Series Super Duty <10K Diesel | chHDDsFIN-(0.2)/ULEV2 | |
| | | DF Vehicle | chHDDsFIN-(0.2)/ULEV2 | |

## ELECTRIC VEHICLE -- DURABILITY GROUPS

| Electric NA -- DURABILITY GROUP 1 | | | | |
|---|---|---|---|---|
| DURABILITY GROUP DFMXEEVNN?1A | | | | 1.0 |
| DFMXV00.0VAE | TBD KW | Focus - BEV | T2B1(ZEV) | |

***Equivalency Factor values calculated in accordance with 40 CFR 1823-08 as ammended in the 11/09/2009 Direc**

# 2013 MY OBD System Operation

# Summary for Gasoline Engines

Table of Contents

# Introduction – OBD-I, OBD-II, HD OBD and EMD

## OBD-I Systems

OBD-I vehicles use the same PCM, CAN serial data communication link, J1962 Data Link Connector, and PCM software as the corresponding OBD-II vehicle. The only difference is the possible removal of the rear oxygen sensor(s), fuel tank pressure sensor, canister vent solenoid, and a different PCM calibration. Starting in the 2006 MY, all Federal vehicles from 8,500 to 14,000 lbs. GVWR will have been phased into OBD-II and OBD-I systems will no longer be utilized in vehicles up to 14,000 lbs GVWR.

## OBD-II Systems

**On Board Diagnostics II - Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines certified under title 13, CCR section 1968.2**

California OBD-II applies to all California and "CAA Sec. 177 States" for gasoline engine vehicles up to 14,000 lbs. Gross Vehicle Weight Rating (GVWR) starting in the 1996 MY and all diesel engine vehicles up to 14,000 lbs. GVWR starting in the 1997 MY.

"CAA Sec. 177 States" or "California States" are states that have adopted and placed into effect the California Air Resources Board (CARB) regulations for a vehicle class or classes in accordance with Section 177 of the Clean Air Act.. At this time, "CAA Sec. 177 States" are Massachusetts, New York, Vermont and Maine for 2004, Rhode Island, Connecticut, Pennsylvania for 2008, New Jersey, Washington, Oregon for 2009, Maryland for 2011, Delaware for 2014 and New Mexico for 2016. These States receive California-certified vehicles for passenger cars and light trucks, and medium-duty vehicles, up to 14,000 lbs. GVWR."

Federal OBD applies to all gasoline engine vehicles up to 8,500 lbs. GVWR starting in the 1996 MY and all diesel engine vehicles up to 8,500 lbs. GVWR starting in the 1997 MY. US Federal only OBD-certified vehicles may use the US Federal allowance to certify to California OBD II but then turn off/disable 0.020" evap leak detection).

Starting in the 2004 MY, Federal vehicle over 8,500 lbs. are required to phase in OBD-II. Starting in 2004 MY, gasoline-fueled Medium Duty Passenger Vehicles (MDPVs) are required to have OBD-II. By the 2006 MY, all Federal vehicles from 8,500 to 14,000 lbs. GVWR will have been phased into OBD-II.

OBD-II system implementation and operation is described in the remainder of this document.

## Heavy Duty OBD Systems

**Heavy Duty On-Board Diagnostics - Heavy-duty engines (>14,000 GVWR) certified to HD OBD under title 13, CCR section 1971.1(d)(7.1.1) or (7.2.2) (i.e., 2010 and beyond model year diesel and gasoline engines that are subject to full HD OBD)**

Starting in the 2010 MY, California and Federal gasoline-fueled and diesel fueled on-road heavy duty engines used in vehicles over 14,000 lbs. GVWR are required to phase into HD OBD. The phase-in starts with certifying one engine family to HD OBD in the 2010 MY. (2010 MY 6.8L 3V Econoline) By the 2013 MY, all engine families must certify to the HD OBD requirements. Vehicles/engines that do not comply with HD OBD during the phase-in period must comply with EMD+.

## EMD Systems

**Engine Manufacturer Diagnostics (EMD) – Heavy duty vehicles (>14,000 GVWR) certified to EMD under title 13, CCR section 1971 (e.g., 2007-2009 model year diesel and gasoline engines)**

Engine Manufacturer Diagnostics (EMD) applies to all 2007 MY and beyond California gasoline-fueled and diesel fueled on-road heavy duty engines used in vehicles over 14,000 lbs Gross Vehicle Weight Rating (GVWR). EMD systems are required to functionally monitor the fuel delivery system, exhaust gas recirculation system, particulate matter trap, as well as emission related ECM input inputs for circuit continuity and rationality, and emission-related outputs for circuit continuity and functionality. For gasoline engines, which have no PM trap, EMD requirements are very similar to current OBD-I system requirements. As such, OBD-I system philosophy will be employed, the only change being the addition of some comprehensive component monitor (CCM) rationality and functionality checks.

**Engine Manufacturer Diagnostics Enhanced (EMD+) - Heavy-duty engines (>14,000 GVWR) certified to EMD+ under title 13, CCR section 1971.1 (e.g., 2010-2012 model year diesel and gasoline engines not certified to HD OBD, 2013-2019 model year alternate fuel engines)**

Starting in the 2010 MY, EMD was updated to require functional monitoring of the NOx aftertreatment system on gasoline engines. This requirement is commonly known as EMD+.

EMD+ vehicles use that same PCM, CAN serial data communication link, J1962 Data Link Connector, and PCM software as the corresponding OBD-II vehicle. The only difference is the possible removal of the fuel tank pressure sensor, canister vent solenoid, and a different PCM calibration.

The following list indicates what monitors and functions have been altered from OBD-II for EMD calibrations:

| Monitor / Feature | Calibration |
|---|---|
| Catalyst Monitor | Functional catalyst monitor required starting in the 2010 MY to meet EMD+. |
| Misfire Monitor | Calibrated in for service, all DTCs are non-MIL. Catalyst damage misfire criteria calibrated out, emission threshold criteria set to 4%, enabled between 150 °F and 220 °F, 254 sec start-up delay. |
| Oxygen Sensor Monitor | Front O2 sensor "lack of switching" tests and all circuit and heater tests calibrated in, response/delay test calibrated out.<br>Rear O2 sensor functional tests and all circuit and heater tests calibrated in, response/delay test calibrated out. |
| EGR/VVT Monitor | Same as OBD-II calibration except that P0402 test uses slightly higher threshold. |
| Fuel System Monitor | Fuel monitor and FAOSC monitor (rear fuel trim for UEGO systems) same as OBD-II calibration, A/F imbalance monitor calibrated out. |
| Secondary Air Monitor | Not applicable, AIR not used. |
| Evap System Monitor | Evap system leak check calibrated out, fuel level input circuit checks retained as non-MIL. Fuel tank pressure sensor and canister vent solenoid may be deleted. |
| PCV Monitor | Same hardware and function as OBD-II. |
| Thermostat Monitor | Thermostat monitor calibrated out. |
| Comprehensive Component Monitor | All circuit checks, rationality and functional tests same as OBD-II. |
| Communication Protocol and DLC | Same as OBD-II, all generic and enhanced scan tool modes work the same as OBD-II but reflect the EMD calibration that contains fewer supported monitors. "OBD Supported" PID indicates EMD ($11). |
| MIL Control | Same as OBD-II, it takes 2 driving cycles to illuminate the MIL. |

EMD system implementation and operation is a subset of OBD-II and is described in the remainder of this document.

## Catalyst Efficiency Monitor

The Catalyst Efficiency Monitor uses an oxygen sensor after the catalyst to infer the hydrocarbon efficiency based on oxygen storage capacity of the ceria and precious metals in the washcoat. Under normal, closed-loop fuel conditions, high efficiency catalysts have significant oxygen storage. This makes the switching frequency of the rear HO2S very slow and reduces the amplitude of those. As catalyst efficiency deteriorates due to thermal and/or chemical deterioration, its ability to store oxygen declines and the post-catalyst HO2S signal begins to switch more rapidly with increasing amplitude. The predominant failure mode for high mileage catalysts is chemical deterioration (phosphorus deposition on the front brick of the catalyst), not thermal deterioration.

### Index Ratio Method Using a Switching HO2S Sensor

In order to assess catalyst oxygen storage, the catalyst monitor counts front HO2S switches during part-throttle, closed-loop fuel conditions after the engine is warmed-up and inferred catalyst temperature is within limits. Front switches are accumulated in up to three different air mass regions or cells. While catalyst monitoring entry conditions are being met, the front and rear HO2S signal lengths are continually being calculated. When the required number of front switches has accumulated in each cell (air mass region), the total signal length of the rear HO2S is divided by the total signal length of front HO2S to compute a catalyst index ratio. An index ratio near 0.0 indicates high oxygen storage capacity, hence high HC efficiency. An index ratio near 1.0 indicates low oxygen storage capacity, hence low HC efficiency. If the actual index ratio exceeds the threshold index ratio, the catalyst is considered failed.

If the catalyst monitor does not complete during a particular driving cycle, the already-accumulated switch/signal-length data is retained in Keep Alive Memory and is used during the next driving cycle to allow the catalyst monitor a better opportunity to complete, even under short or transient driving conditions.

If the catalyst monitor runs to completion during a driving cycle, it will be allowed to run again and collect another set of data during the same driving cycle. This would allow the catalyst monitor to complete up to a maximum of two times per driving cycle, however, the in-use performance ratio numerator for the catalyst monitor will only be allowed to increment once per driving cycle. For example, if the catalyst monitor completes twice during the current driving cycle, the catalyst monitor in-use performance numerator will be incremented once during the current driving cycle and will incremented again for the second completion on the following driving cycle, after the catalyst monitor entry condition have been met.

### Index Ratio Method Using a Wide Range HO2S Sensor (UEGO)

The switching HO2S control system compares the HO2S signals before and after the catalyst to assess catalyst oxygen storage. The front HO2S signal from UEGO control system is used to control to a target A/F ratio and does not have "switches" As a result, a new method of catalyst monitor is utilized.

The UEGO catalyst monitor is an active/intrusive monitor. The monitor performs a calibratable 10-20 second test during steady state rpm, load and engine air mass operating conditions at normal vehicle speeds. During the test, the fuel control system remains in closed loop, UEGO control with fixed system gains. In order to assess catalyst oxygen storage, the UEGO catalyst monitor is enabled during part-throttle, closed-loop fuel conditions after the engine is warmed-up and inferred catalyst temperature is within limits. While the catalyst monitoring entry conditions are being met, the rear HO2S signal length is continually being calculated. When the required total calibrated time has been accumulated, the total voltage signal length of the rear HO2S is divided by a calibrated threshold rear HO2S signal length to compute a catalyst index ratio. The threshold rear HO2S signal is calibrated as a function of air mass using a with a catalyst with no precious metal. This catalyst defines the worst case signal length because it has no oxygen storage. If the monitored catalyst has sufficient oxygen storage, little activity is observed on the rear HO2S voltage signal. An index ratio near 0.0 indicates high oxygen storage capacity, hence high HC/NOx efficiency. As catalyst oxygen storage degrades, the rear HO2S voltage signal activity increases. An index ratio near, 1.0 indicates low oxygen storage capacity, hence low HC/NOx efficiency. If the actual index ratio exceeds the calibrated threshold ratio, the catalyst is considered failed.

## Integrated Air/Fuel Method

The Integrated Air/Fuel Catalyst Monitor assesses the oxygen storage capacity of a catalyst after a fuel cut event. The monitor integrates how much excess fuel is needed to drive the monitored catalyst to a rich condition starting from an oxygen-saturated, lean condition. Therefore, the monitor is a measure of how much fuel is required to force catalyst breakthrough from lean to rich. To accomplish this, the monitor runs during fuel reactivation following a Decel Fuel Shut Off (DFSO) event. The monitor completes after a calibrated number of DFSO monitoring events have occurred. The IAF catalyst monitor can be used with either a wide range O2 sensor (UEGO) or a conventional switching sensor (HEGO).

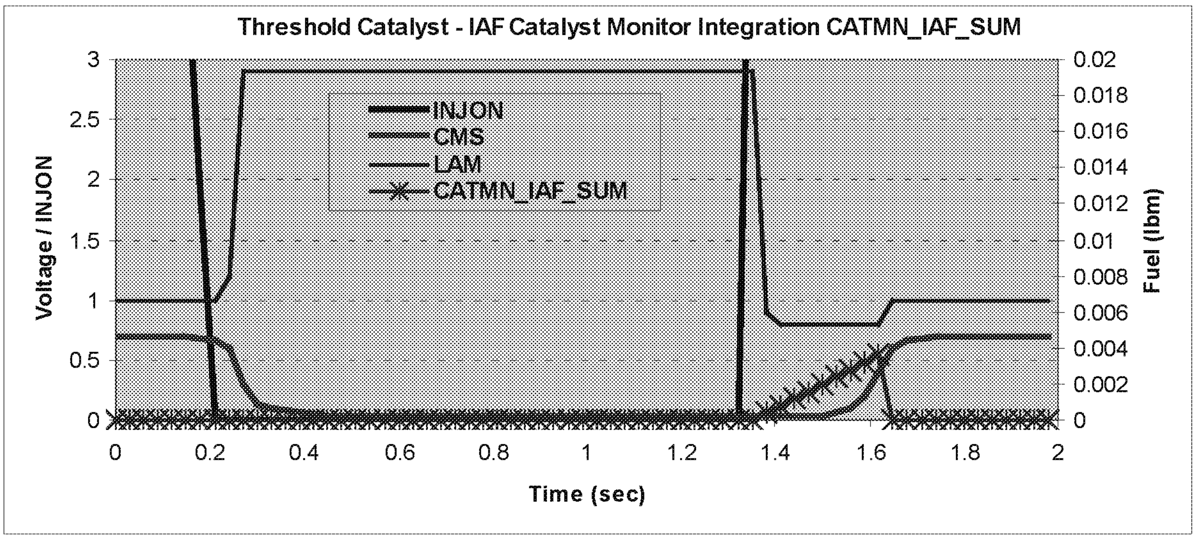
Functionally, the equation is:

$$IAF = \int\left(\frac{Fuel\_needed\_for\_stoich}{Fuel\_Measured} - Fuel\_needed\_for\_stoich\right)$$

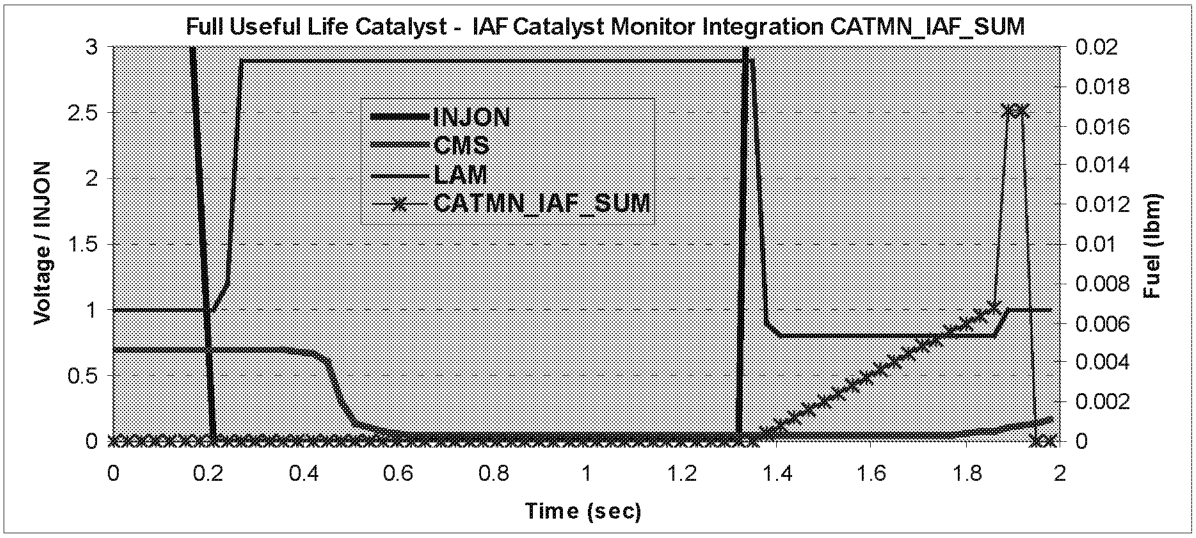
where the units are in pounds mass of fuel.

The monitor runs during reactivation fueling following an injector cut. The diagram below shows examples of one DFSO event with a threshold catalyst and with a Full Useful Life catalyst where:

- INJON = # of injectors on.
- CMS is the catalyst monitor sensor voltage. When the rear O2 sensor crosses 0.45 volts (i.e. rich) the monitor will complete for the given DFSO event.
- LAM (LAMBDA) is the front O2 sensor (UEGO) signal.
- CATMN_IAF_SUM is the integral from the equations above (Y axis on the right).




In this example, CATMN_IAF_SUM is small because it doesn't take much fuel to break though a low oxygen storage threshold catalyst.




In this example, CATMN_IAF_SUM is much larger because it takes a substantial amount of fuel to break though a high oxygen storage threshold catalyst.

There are two sets of entry conditions into the IAF catalyst monitor. The high level entry conditions determine that the monitor would like to run following the next injector fuel cut event. The lower level entry conditions determine that the fuel cut-off event was suitable for monitoring and the monitor will run as soon as the injectors come back on.

1. The high level entry conditions are met when:

- There are no senor/hardware faults
- The base monitor entry conditions have been met (ECT, IAT, cat temp, fuel level, air mass)
- Required number of DFSO monitoring event have not yet completed

2. The lower level entry conditions are met when:

- The injectors are off
- The catalyst is believed to be saturated with oxygen (rear O2 indicates lean)
- The catalyst/rear O2 has been rich at least once since the last monitor event.

## General Catalyst Monitor Operation

Rear HO2S sensors can be located in various ways to monitor different kinds of exhaust systems. In-line engines and many V-engines are monitored by individual bank. A rear HO2S sensor is used along with the front, fuel-control HO2S sensor for each bank. Two sensors are used on an in-line engine; four sensors are used on a V-engine. Some V-engines have exhaust banks that combine into a single underbody catalyst. These systems are referred to as Y-pipe systems. They use only one rear HO2S sensor along with the two front, fuel-control HO2S sensors. Y-pipe system use three sensors in all. For Y-pipe systems which utilize switching front O2 sensors, the two front HO2S sensor signals are combined by the software to infer what the HO2S signal would have been in front of the monitored catalyst. The inferred front HO2S signal and the actual single, rear HO2S signal is then used to calculate the switch ratio.

Many vehicles monitor less than 100% of the catalyst volume – often the first catalyst brick of the catalyst system. Partial volume monitoring is done on LEV-II vehicles in order to meet the 1.75 * emission-standard threshold for NMHC and NOx. The rationale for this practice is that the catalysts nearest the engine deteriorate first, allowing the catalyst monitor to be more sensitive and illuminate the MIL properly at lower emission standards.

Many applications that utilize partial-volume monitoring place the rear HO2S sensor after the first light-off catalyst can or, after the second catalyst can in a three-can per bank system. (A few applications placed the HO2S in the middle of the catalyst can, between the first and second bricks.)

The new Integrated Air/Fuel Catalyst Monitor can be used to monitor the entire catalyst volume, even on LEV-II vehicles.

Index ratios for ethanol (Flex fuel) vehicles vary based on the changing concentration of alcohol in the fuel. The malfunction threshold typically increases as the percent alcohol increases. For example, a malfunction threshold of 0.5 may be used at E10 (10% ethanol) and 0.9 may be used at E85 (85% ethanol). The malfunction thresholds are therefore adjusted based on the % alcohol in the fuel. (Note: Normal gasoline is allowed to contain up to 10% ethanol (E10)).

Vehicles with the Index Ratio Method Using a Switching HO2S Sensor employ an Exponentially Weighted Moving Average (EWMA) algorithm to improve the robustness of the catalyst monitor. During normal customer driving, a malfunction will illuminate the MIL, on average, in 3 to 6 driving cycles. If KAM is reset (battery disconnected) or DTCs are cleared, a malfunction will illuminate the MIL in 2 driving cycles. See the section on EWMA for additional information.

Vehicles with the Index Ratio Method Using a Wide Range HO2S Sensor (UEGO) or the Integrated Air/Fuel catalyst monitor employ an improved version of the EWMA algorithm.

The EWMA logic incorporates several important CARB requirements. These are:

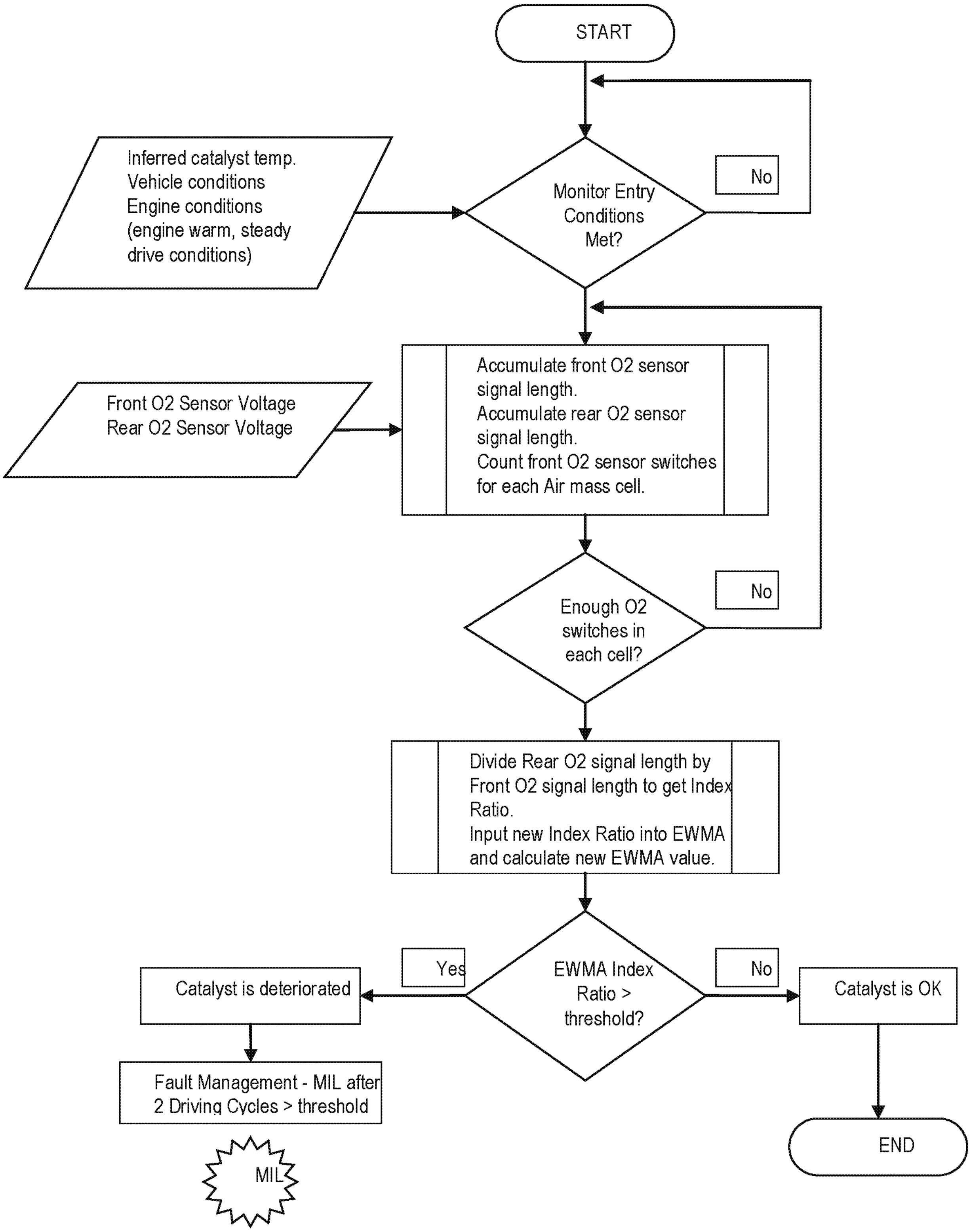
- Fast Initial Response (FIR): The first 4 tests after a battery disconnect or code clear will process unfiltered data to quickly indicate a fault. The FIR will use a 2-trip MIL. This will help the service technician determine that a fault has been fixed.
- Step-change Logic (SCL): The logic will detect an abrupt change from a no-fault condition to a fault condition. The SCL will be active after the 4$^{th}$ catalyst monitor cycle and will also use a 2-trip MIL. This will illuminate the MIL when a fault is instantaneously induced.
- Normal EWMA (NORM): This is the normal mode of operation and uses an Exponentially Weighted Moving Average (EWMA) to filter the catalyst monitor test data. It is employed after the 4$^{th}$ catalyst test and will illuminate a MIL during the drive cycle where the EWMA value exceeds the fault threshold. (1 trip MIL).

Starting in the 2010 ½ Model Year and later, the catalyst monitor will employ catalyst break-in logic. This logic will prevent the catalyst monitor from running until after a catalyst break-in period.

The catalyst monitor will not run on a new vehicle from the assembly plant until 60 minutes of time above a catalyst temperature (typically 800 to 1100 deg F) has been accumulated or 300 miles has elapsed.

New modules at the assembly plant will have an NVRAM flag initialized to delay the catalyst monitor. Service modules and re-flash software will have the flag set to allow that catalyst monitor to run. The flag cannot be reset to delay the catalyst monitor from running by any tool or service procedure.

# Index Ratio Catalyst Monitor



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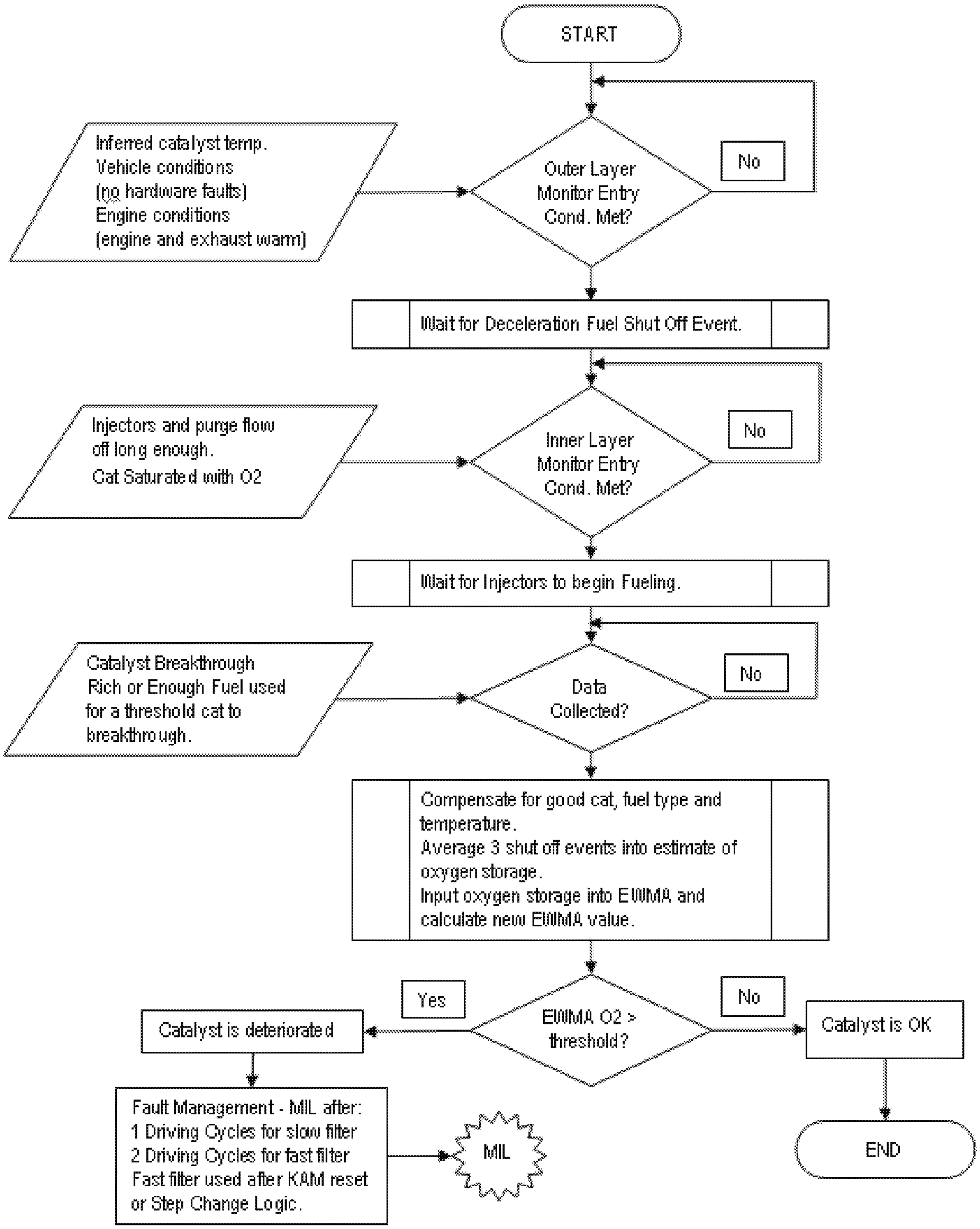

START
Inferred catalyst temp.
Vehicle conditions
(no hardware faults)
Engine conditions
(engine and exhaust warm)
Outer Layer Monitor Entry Cond. Met?
No
Wait for Deceleration Fuel Shut Off Event.
Injectors and purge flow off long enough.
Cat Saturated with O2
Inner Layer Monitor Entry Cond. Met?
No
Wait for Injectors to begin Fueling.
Catalyst Breakthrough Rich or Enough Fuel used for a threshold cat to breakthrough.
Data Collected?
No
Compensate for good cat, fuel type and temperature.
Average 3 shut off events into estimate of oxygen storage.
Input oxygen storage into EWMA and calculate new EWMA value.
EWMA O2 > threshold?
Yes
No
Catalyst is deteriorated
Catalyst is OK
Fault Management - MIL after:
1 Driving Cycles for slow filter
2 Driving Cycles for fast filter
Fast filter used after KAM reset or Step Change Logic.
MIL
END

| CATALYST MONITOR OPERATION: | |
|---|---|
| DTCs | P0420 Bank 1 (or Y-pipe), P0430 Bank 2 |
| Monitor execution | once per driving cycle |
| Monitor Sequence | HO2S response test complete and no DTCs (P0133/P0153) prior to calculating switch ratio, no SAIR pump stuck on DTCs (P0412/P1414), no evap leak check DTCs (P0442/P0456), no EGR stuck open DTCs (P0402) |
| Sensors OK | ECT, IAT, TP, VSS, CKP, MAF, no misfire DTCs (P0300, P0310), no ignition coil DTCs (P0351-P0358), no fuel monitor DTCs (P0171, P0172, P0174. P0175), no VCT DTCs (P0010-P0017, P052A, P052B, P0344, P0365, P0369-bank1) (P0018 thru P0025,P052C, P052D, P0349, P0390, P0394- bank2 ).no evap system DTCs (P0443, P0446, P0455, P0457, P1450), no ETC system DTCs (P0122, P0123, P0222, P0223, P02135) (P2101, P2107, P2111, P2112) (P0600, P060A, P060B, P060C, P061B, P061C, P061D, P1674, U0300). |
| Monitoring Duration | Approximately 700 seconds during appropriate FTP conditions (approximately 100 to 200 oxygen sensor switches are collected) for switching O2 control sensors<br><br>Approximately 10 to 20 seconds for wide range O2 index ratio monitor.<br><br>3 Decel Fuel Cutoff events for IAF catalyst monitor |

| TYPICAL SWITCHING O2 SENSOR INDEX RATIO CATALYST MONITOR ENTRY CONDITIONS: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Time since engine start-up (70 °F start) | 330 seconds | |
| Engine Coolant Temp | 170 °F | 230 °F |
| Intake Air Temp | 20 °F | 180 °F |
| Time since entering closed loop fuel | 30 sec | |
| Inferred Rear HO2S sensor Temperature | 900 °F | |
| EGR flow (Note: an EGR fault disables EGR) | 1% | 12% |
| Throttle Position | Part Throttle | Part Throttle |
| Rate of Change of Throttle Position | | 0.2 volts / 0.050 s |
| Vehicle Speed | 5 mph | 70 mph |
| Fuel Level | 15% | |
| First Air Mass Cell | 1.0 lb/min | 2.0 lb/min |
| Engine RPM for first air mass cell | 1,000 rpm | 1,300 rpm |
| Engine Load for first air mass cell | 15% | 35% |
| Monitored catalyst mid-bed temp. (inferred) for first air mass cell | 850 °F | 1,200 °F |
| Number of front O2 switches required for first air mass cell | 50 | |
| Second Air Mass Cell | 2.0 lb/min | 3.0 lb/min |
| Engine RPM for second air mass cell | 1,200 rpm | 1,500 rpm |
| Engine Load for second air mass cell | 20% | 35% |
| Monitored catalyst mid-bed temp. (inferred) for second air mass cell | 900 °F | 1,250 °F |
| Number of front O2 switches required for second air mass cell | 70 | |

| | | |
|---|---|---|
| Third Air Mass Cell | 3.0 lb/min | 4.0 lb/min |
| Engine RPM for third air mass cell | 1,300 rpm | 1,600 rpm |
| Engine Load for third air mass cell | 20% | 40% |
| Monitored catalyst mid-bed temp. (inferred) for third air mass cell | 950 °F | 1,300 °F |
| Number of front O2 switches required for third air mass cell | 30 | |
| (Note: Engine rpm and load values for each air mass cell can vary as a function of the power-to-weight ratio of the engine, transmission and axle gearing and tire size.) | | |

| TYPICAL WIDE RANGE O2 SENSOR INDEX RATIO CATALYST MONITOR ENTRY CONDITIONS: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Time since engine start-up (70 °F start) | 330 seconds | |
| Engine Coolant Temp | 170 °F | 230 °F |
| Intake Air Temp | 20 °F | 180 °F |
| Time since entering closed loop fuel | 30 sec | |
| Inferred Rear HO2S sensor Temperature | 900 °F | |
| EGR flow (Note: an EGR fault disables EGR) | 1% | 12% |
| Throttle Position | Part Throttle | Part Throttle |
| Rate of Change of Throttle Position | | 0.2 volts / 0.050 s |
| Vehicle Speed | 20 mph | 80 mph |
| Fuel Level | 15% | |
| Air Mass | 2.0 lb/min | 5.0 lb/min |
| Engine RPM | 1,000 rpm | 2,000 rpm |
| Engine Load | 20% | 60% |
| Monitored catalyst mid-bed temp. (inferred) for first air mass cell | 850 °F | 1,200 °F |
| (Note: Engine rpm, load and air mass values can vary as a function of the power-to-weight ratio of the engine, transmission and axle gearing and tire size.) | | |

| TYPICAL IAF CATALYST MONITOR ENTRY CONDITIONS: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Coolant Temp | 160 °F | 230 °F |
| Intake Air Temp | 20 °F | 140 °F |
| Inferred catalyst mid-bed temperature | 900 °F | 1500 °F |
| Fuel Level | 15% | |
| Air Mass | | 2.0 lb/min |
| Minimum inferred rear O2 sensor temperature | 800 °F | |
| Fuel monitor learned within limits | 97% | 103% |
| Rear O2 sensor rich since last monitor attempt | 0.45 volts | |
| Rear O2 sensor lean with injectors off (voltage needed to enter monitor) | | 0.1 volts |
| Rear O2 sensor reads rich after fuel turned back on (voltage needed to complete monitor) | 0.45 volts | |

| TYPICAL MALFUNCTION THRESHOLDS: |
|---|
| Catalyst monitor index ratio > 0.75 (bank monitor) |
| Catalyst monitor index-ratio > 0.60 (Y-pipe monitor) |
| Catalyst monitor index ratio > 0.50 for E10 to > 0.90 for E85 (flex fuel vehicles) |

Mode $06 reporting for IAF Catalyst Monitor

The catalyst monitor results are converted to a ratio for Mode $06 reporting to keep the same look and feel for the service technician. The equation for calculating the Mode $06 monitor result is:

1 – (Actual reactivation fuel/ Good catalyst reactivation fuel)

Good catalyst reactivation fuel is intended to represent what the monitor would measure for a green catalyst.

| J1979 CATALYST MONITOR MODE $06 DATA | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| $21 | $80 | Bank 1 index-ratio and max. limit (P0420/P0430) | unitless |
| $22 | $80 | Bank 2 index-ratio and max. limit (P0420/P0430) | unitless |

** NOTE: In this document, a monitor or sensor is considered OK if there are no DTCs stored for that component or system at the time the monitor is running.

# Misfire Monitor

There are two different misfire monitoring technologies used in the 2009 MY. They are Low Data Rate (LDR), and High Data Rate (HDR). The LDR system is capable of meeting the FTP monitoring requirements on most engines and is capable of meeting "full-range" misfire monitoring requirements on 4-cylinder engines. The HDR system is capable of meeting "full-range" misfire monitoring requirements on 6 and 8 cylinder engines. All software allows for detection of any misfires that occur 6 engine revolutions after initially cranking the engine. This meets the OBD-II requirement to identify misfires within 2 engine revolutions after exceeding the warm drive, idle rpm.

## Low Data Rate System

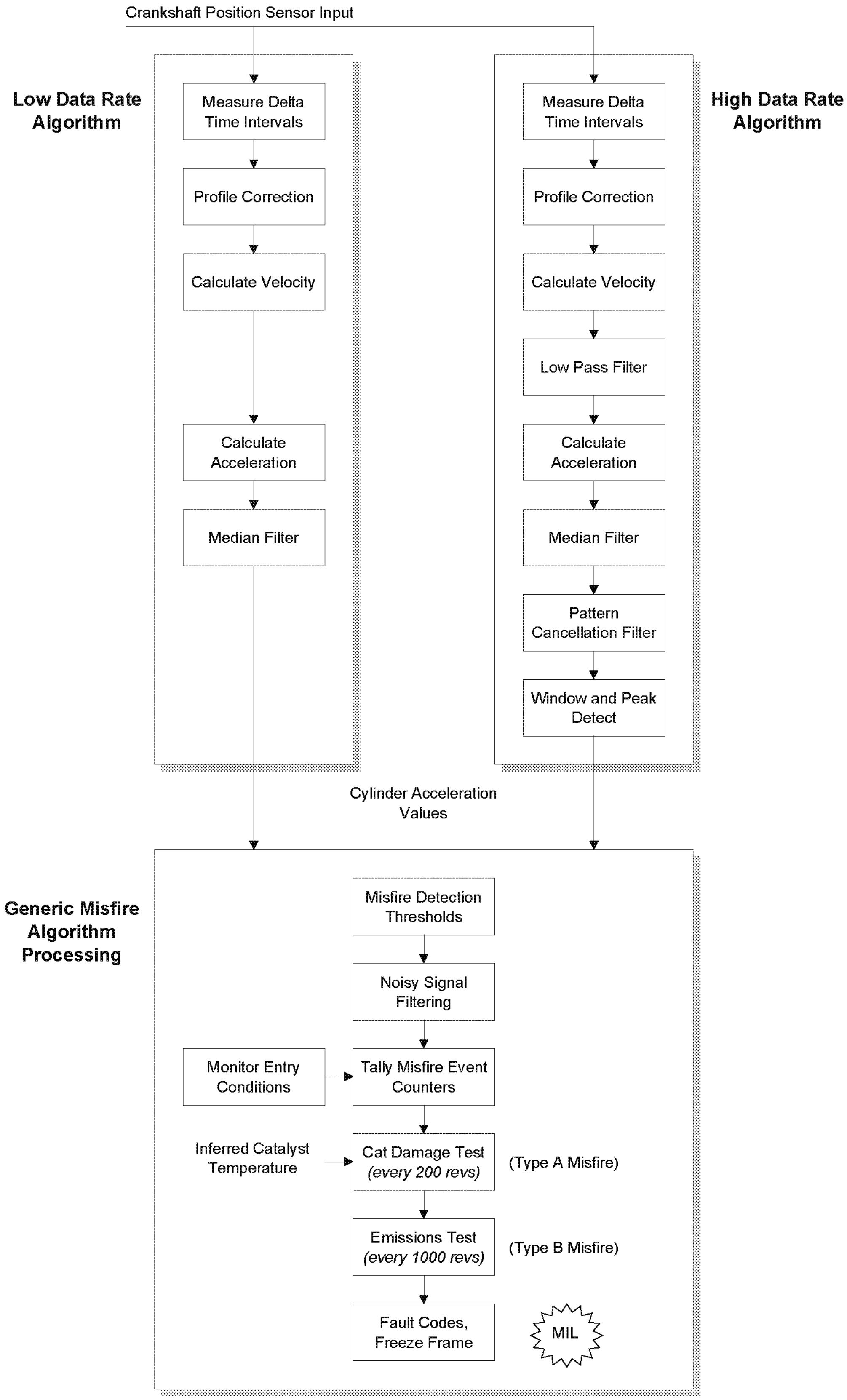
The LDR Misfire Monitor uses a low-data-rate crankshaft position signal, (i.e. one position reference signal at 10 deg BTDC for each cylinder event). The PCM calculates crankshaft rotational velocity for each cylinder from this crankshaft position signal. The acceleration for each cylinder can then be calculated using successive velocity values. The changes in overall engine rpm are removed by subtracting the median engine acceleration over a complete engine cycle. The crankshaft acceleration is then processed by two algorithms. The first is optimized for detection of sporadic and single cylinder patterns of misfire; the second is optimized for multi-cylinder patterns. The resulting deviant cylinder acceleration values are used in evaluating misfire in the "General Misfire Algorithm Processing" section below.

## High Data Rate System

The High Data Rate (HDR) Misfire Monitor uses a high data rate crankshaft position signal, (i.e. 18 position references per crankshaft revolution). This high-resolution signal is processed using two different algorithms. The first algorithm is optimized to detect "hard" misfires, i.e. one or more continuously misfiring cylinders. The low pass filter filters the high-resolution crankshaft velocity signal to remove some of the crankshaft torsional vibrations that degrade signal to noise. Two low pass filters are used to enhance detection capability – a "base" filter and a more aggressive filter to enhance single-cylinder capability at higher rpm. This significantly improves detection capability for continuous misfires on single cylinders up to redline. The second algorithm, called pattern cancellation, is optimized to detect low rates of misfire. The algorithm learns the normal pattern of cylinder accelerations from the mostly good firing events and is then able to accurately detect deviations from that pattern. Both the hard misfire algorithm and the pattern cancellation algorithm produce a deviant cylinder acceleration value, which is used in evaluating misfire in the "General Misfire Algorithm Processing" section below.

Due to the high data processing requirements, the HDR algorithm may be implemented by the PCM in a separate chip. The chip performs the HDR algorithm calculations and sends the deviant cylinder acceleration values to the PCM microprocessor for additional processing as described below. The chip requires proper operation of the crank and cam sensor inputs. A P1336 will be set if the chip detects noise on the crank sensor input, or if the chip is unable to synchronize with the missing tooth location.. A P1336 points noise present on the crank sensor input or a lack of synchronization between the cam and crank sensors.

## Low Data Rate and High Data Rate Systems



## Generic Misfire Algorithm Processing

The acceleration that a piston undergoes during a normal firing event is directly related to the amount of torque that cylinder produces. The calculated piston/cylinder acceleration value(s) are compared to a misfire threshold that is continuously adjusted based on inferred engine torque. Deviant accelerations exceeding the threshold are conditionally labeled as misfires. A threshold multiplier is used during startup CSER to compensate the thresholds for the reduction in signal amplitude during spark retard conditions.

The calculated deviant acceleration value(s) are also evaluated for noise. Normally, misfire results in a non-symmetrical loss of cylinder acceleration. Mechanical noise, such as rough roads or high rpm/light load conditions, will produce symmetrical, positive acceleration variations. A noise limit is calculated by applying a negative multiplier to the misfire threshold. If the noise limit is exceeded, a noisy signal condition is inferred and the misfire monitor is suspended for a brief interval. Noise-free deviant acceleration exceeding a given threshold is labeled a misfire.

The number of misfires is counted over a continuous 200 revolution and 1000 revolution period. (The revolution counters are not reset if the misfire monitor is temporarily disabled such as for negative torque mode, etc.) At the end of the evaluation period, the total misfire rate and the misfire rate for each individual cylinder is computed. The misfire rate evaluated every 200 revolution period (Type A) and compared to a threshold value obtained from an engine speed/load table. This misfire threshold is designed to prevent damage to the catalyst due to sustained excessive temperature (1650°F for Pt/Pd/Rh advanced washcoat and 1800°F for Pd-only high tech washcoat). If the misfire threshold is exceeded and the catalyst temperature model calculates a catalyst mid-bed temperature that exceeds the catalyst damage threshold, the MIL blinks at a 1 Hz rate while the misfire is present. If the misfire occurs again on a subsequent driving cycle, the MIL is illuminated.

If a single cylinder is determined to be consistently misfiring in excess of the catalyst damage criteria, the fuel injector to that cylinder will be shut off for 30 seconds to prevent catalyst damage. Up to two cylinders may be disabled at the same time on 6 and 8 cylinder engines and one cylinder is disabled on 4 cylinder engines. This fuel shut-off feature is used on all engines starting in the 2005 MY. After 30 seconds, the injector is re-enabled. If misfire on that cylinder is again detected after 200 revs (about 5 to 10 seconds), the fuel injector will be shut off again and the process will repeat until the misfire is no longer present. Note that ignition coil primary circuit failures (see CCM section) will trigger the same type of fuel injector disablement.

The misfire rate is also evaluated every 1000 rev period and compared to a single (Type B) threshold value to indicate an emission-threshold malfunction, which can be either a single 1000 rev exceedence from startup or four subsequent 1000 rev exceedences on a drive cycle after start-up. Some vehicles will set a P0316 DTC if the Type B malfunction threshold is exceeded during the first 1,000 revs after engine startup. This DTC is normally stored in addition to the normal P03xx DTC that indicates the misfiring cylinder(s). If misfire is detected but cannot be attributed to a specific cylinder, a P0300 is stored. This may occur on some vehicles at higher engine speeds, for example, above 3,500 rpm.

## Rough Road Detection

The Misfire Monitor includes a Rough Road Detection (RRD) system to eliminate false misfire indications due to rough road conditions. The RRD system uses data from ABS wheel speed sensors for estimating the severity of rough road conditions. This is a more direct measurement of rough road over other methods which are based on driveline feedback via crankshaft velocity measurements. It improves accuracy over these other methods since it eliminates interactions with actual misfire.

In the event of an RRD system failure, the RRD output will be ignored and the Misfire Monitor will remain active. An RRD system failure could be caused by a failure in any of the input signals to the algorithm. This includes the ABS wheel speed sensors, Brake Pedal sensor, or CAN bus hardware failures. Specific DTCs will indicate the source of these component failures.

A redundant check is also performed on the RRD system to verify it is not stuck high due to other unforeseen causes. If the RRD system indicates rough road during low vehicle speed conditions where it is not expected, the RRD output will be ignored and the Misfire Monitor will remain active.

## Profile Correction

"Profile correction" software is used to "learn" and correct for mechanical inaccuracies in the crankshaft position wheel tooth spacing. Since the sum of all the angles between crankshaft teeth must equal 360°, a correction factor can be calculated for each misfire sample interval that makes all the angles between individual teeth equal. . The LDR misfire system will learn one profile correction factor per cylinder (ex. 4 correction factors for a 4 cylinder engine), while the HDR system will learn 36 or 40 correction factors depending on the number of crankshaft wheel teeth (ex. 36 for V6/V8 engines, 40 for V10 engines).

The corrections are calculated from several engine cycles of misfire sample interval data. The "mature" correction factors are the average of a selected number of samples. In order to assure the accuracy of these corrections, a tolerance is placed on the incoming values such that an individual correction factor must be repeatable within the tolerance during learning. This is to reduce the possibility of learning corrections on rough road conditions which could limit misfire detection capability and to help isolate misfire diagnoses from other crankshaft velocity disturbances.

To prevent any fueling or combustion differences from affecting the correction factors, learning is done during decel-fuel cutout. This can be done during closed-throttle, non-braking, de-fueled decelerations in the 60 to 40 mph range after exceeding 60 mph (likely to correspond to a freeway exit condition). In order to minimize the learning time for the correction factors, a more aggressive decel-fuel cutout strategy may be employed when the conditions for learning are present and are typically learned in a single 60 to 40 MPH deceleration, but can be learned during up to 3 such decelerations, or over a higher number of shorter duration decelerations..

For Hybrid Electric Vehicles profile is learned by using the electric drive to spin the crankshaft on the first engine shutdown during which time profile is calculated.

Since inaccuracies in the wheel tooth spacing can produce a false indication of misfire, the misfire monitor is not active until the corrections are learned. In the event of battery disconnection or loss of Keep Alive Memory the correction factors are lost and must be relearned. If the software is unable to learn a profile after three 60 to 40 mph decels, a P0315 DTC is set.

## Neutral Profile Correction and Non-Volatile Memory

Neutral profile learning is used at End of Line to learn profile correction via a series of one or more neutral engine rpm throttle snaps. This allows the Misfire Monitor to be activated at the Assembly Plant. A Test Tool command is required to enable this method of learning, so this method will only be performed by a Plant or Service technician. Learning profile correction factors at high-speed (3,000 rpm) neutral conditions versus during 60-40 mph decels optimizes correction factors for higher rpms where they are most needed and eliminates driveline/transmission and road noise effects. This improves signal to noise characteristics which means improved detection capability.

The profile correction factors learned at the Assembly Plant are stored into non-volatile memory. This eliminates the need for specific customer drive cycles. However, misfire profiles may need to be relearned in the Service Bay using a service procedure if major engine work is done or the PCM is replaced. (Re-learning is not required for a reflash.)

The 60-40 mph decel profile learning algorithm has been left active in the software on many applications as a backup.

| Misfire Monitor Operation: | |
|---|---|
| DTCs | P0300 to P0310 (general and specific cylinder misfire)<br>P1336 (noisy crank sensor, no cam/crank synchronization)<br>P0315 (unable to learn profile)<br>P0316 (misfire during first 1,000 revs after start-up) |
| Monitor execution | Continuous, misfire rate calculated every 200 or 1000 revs |
| Monitor Sequence | None |
| Sensors OK | CKP, CMP, MAF, ECT/CHT |
| Monitoring Duration | Entire driving cycle (see disablement conditions below) |

| Typical misfire monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Time since engine start-up | 0 seconds | 0 seconds |
| Engine Coolant Temperature | 20 $^{o}$F | 250 $^{o}$F |
| RPM Range (Full-Range Misfire certified, with 2 rev delay) | 2 revs after exceeding 150 rpm below “drive” idle rpm | redline on tach or fuel cutoff |
| Profile correction factors learned in NVRAM | Yes | |
| Fuel tank level | 15% | |

| Typical misfire temporary disablement conditions: |
|---|
| Temporary disablement conditions: |
| Closed throttle decel (negative torque, engine being driven) > -100 ft lbs |
| Fuel shut-off due to vehicle-speed limiting or engine-rpm limiting mode |
| High rate of change of torque (heavy throttle tip-in or tip out) > -450 deg/sec or 250 deg/sec; > -200 ft lbs/sec or > 250 ft lbs/sec |
| Rough Road conditions present |

| Typical misfire monitor malfunction thresholds: |
|---|
| Type A (catalyst damaging misfire rate): misfire rate is an rpm/load table ranging from 40% at idle to 4% at high rpm and loads |
| Type B (emission threshold rate): 0.9% to 1.5% |

| J1979 Misfire Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| A1 | $80 | Total engine misfire and catalyst damage misfire rate (updated every 200 revolutions) (P030x) | percent |
| A1 | $81 | Total engine misfire and emission threshold misfire rate (updated every 1,000 revolutions) (P030x) | percent |
| A1 | $82 | Highest catalyst-damage misfire and catalyst damage threshold misfire rate (updated when DTC set or clears) (P030x) | percent |
| A1 | $83 | Highest emission-threshold misfire and emission threshold misfire rate (updated when DTC set or clears) (P030x) | percent |
| A1 | $84 | Inferred catalyst mid-bed temperature (P030x) | $^{o}$C |
| A2 – AD | $0B | EWMA misfire counts for last 10 driving cycles (P030x) | events |
| A2 – AD | $0C | Misfire counts for last/current driving cycle (P030x) | events |
| A2 – AD | $80 | Cylinder X misfire rate and catalyst damage misfire rate (updated every 200 revolutions) (P030x) | percent |
| A2 – AD | $81 | Cylinder X misfire rate and emission threshold misfire rate (updated every 1,000 revolutions) (P030x) | percent |

| Profile Correction Operation | |
|---|---|
| DTCs | P0315 - unable to learn profile in three 60 to 40 mph decels |
| Monitor Execution | Once per profile learning sequence. |
| Monitor Sequence: | Profile must be learned before misfire monitor is active. |
| Sensors OK: | CKP, CMP, CKP/CMP in synch |
| Monitoring Duration; | 10 cumulative seconds in conditions<br>(a maximum of three 60-40 mph defueled decels) |

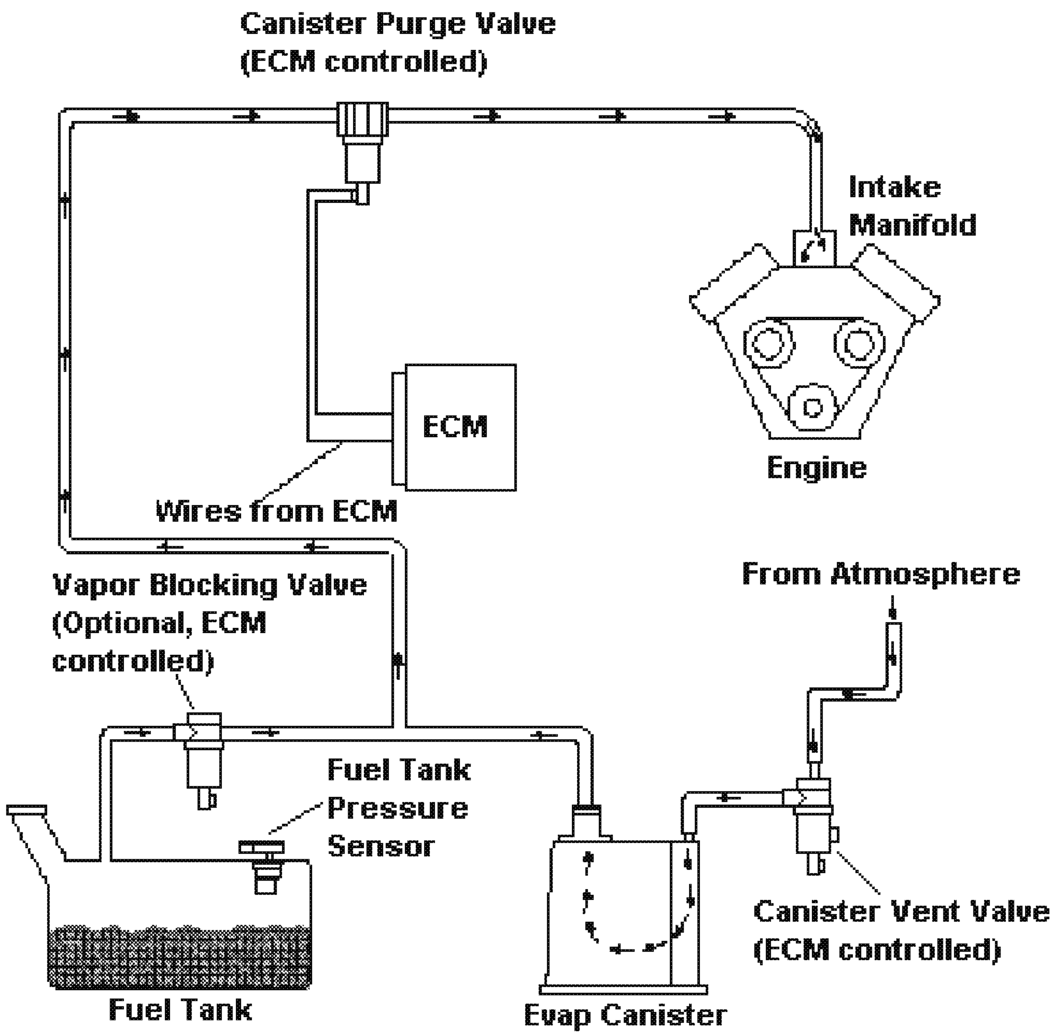
| Typical profile learning entry conditions (Customer drive cycle): | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine in decel-fuel cutout mode for 4 engine cycles | | |
| Brakes applied (Brake On/Off Switch) | No | No |
| Engine RPM | 1300 rpm | 3700 rpm |
| Change in RPM | | 600 rpm/background loop |
| Vehicle Speed | 30 mph | 75 mph |
| Learning tolerance | | 1% |

| Typical profile learning entry conditions (Assembly Plant or Service Bay): | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine in decel-fuel cutout mode for 4 engine cycles | | |
| Park/Neutral gear | | |
| Engine RPM | 2000 rpm | 3000 rpm |
| Learning tolerance | | 1% |

## EVAP System Monitor - 0.040" dia. Vacuum Leak Check

Vehicles that meet enhanced evaporative requirements utilize a vacuum-based evaporative system integrity check. The evap system integrity check uses a Fuel Tank Pressure Transducer (FTPT), a Canister Vent Solenoid (CVS) and Fuel Level Input (FLI) along with a Canister Purge Valve (CPV) to find 0.040" diameter or larger evap system leaks. Federal vehicles can utilize a 0.040" leak check rather than the 0.020" leak check required for California vehicles. Additionally, some programs may elect to run a 0.090" / 0.020" detection configuration and turn the 0.040" leak test off as provided for in the regulations.

In the case of heavy duty gasoline engines (> 14,000 lbs), the regulations require 0.150" leak detection only. Heavy Duty vehicle will not set a P0442 (0.040" leak). They will set a P0455 during the initial vacuum pulldown phase to meet the 0.0150" leak detection requirement.



The evap system integrity test is done under conditions that minimize vapor generation and fuel tank pressure changes due to fuel slosh since these could result in false MIL illumination. The check is run after a 6 hour cold engine soak (engine-off timer), during steady highway speeds at ambient air temperatures (inferred by IAT) between 40 and 100 $^{o}$F.

A check for refueling events is done at engine start. A refuel flag is set in KAM if the fuel level at start-up is at least 20% of total tank capacity greater than fuel fill at engine-off. It stays set until the evap monitor completes Phase 0 of the test as described below. Note that on some vehicles, a refueling check may also be done continuously, with the engine running to detect refueling events that occur when the driver does not turn off the vehicle while refueling (in-flight refueling).

The evap system integrity test is done in four phases.

## (Phase 0 - initial vacuum pulldown):

First, the Canister Vent Solenoid is closed to seal the entire evap system, and then the Canister Purge Valve (CPV) is opened to pull an 8" $H_2O$ vacuum. If the initial vacuum could not be achieved, a large system leak is indicated (P0455). This could be caused by a fuel cap that was not installed properly, a stuck open Capless Fuel Fill valve, a large hole, an overfilled fuel tank, disconnected/kinked vapor lines, a Canister Vent Solenoid that is stuck open, a CPV that is stuck closed, or a disconnected/blocked vapor line between the CPV and the FTPT.

Note: 2009 Model Year and beyond implementations require 2 or 3 gross leak failures in-a-row prior to setting a P0455 DTC.

On some vehicles, if the initial vacuum could not be achieved after a refueling event, a gross leak, fuel cap off (P0457) is indicated and the recorded minimum fuel tank pressure during pulldown is stored in KAM. A “Check Fuel Cap” light may also be illuminated. On vehicles with capless fuel fill, a message instructing the customer to check the Capless Fuel Fill valve will appear in conjunction with a P0457 DTC. Depending on calibration, the MIL may be illuminated in two or three trips with a P0457 failure.

If the initial vacuum is excessive, a vacuum malfunction is indicated (P1450). This could be caused by kinked vapor lines or a stuck open CPV. If a P0455, P0457, or P1450 code is generated, the evap test does not continue with subsequent phases of the small leak check, phases 1-4.

Note: Not all vehicles will have the P0457 test or the Check Fuel Cap light implemented. These vehicles will continue to generate only a P0455. After the customer properly secures the fuel cap, the P0457, Check Fuel Cap and/or MIL will be cleared as soon as normal purging vacuum exceeds the P0457 vacuum level stored in KAM.

## Phase 1 - Vacuum stabilization

If the target vacuum is achieved, the CPV is closed and vacuum is allowed to stabilize for a fixed time. If the pressure in the tank immediately rises, the stabilization time is bypassed and Phase 2 of the test is entered.

Some software has incorporated a "leaking" CPV test, which will also set a P1450 (excessive vacuum) DTC. This test is intended to identify a CPV that does not seal properly, but is not fully stuck open. If more than 1 " $H_2O$ of additional vacuum is developed in Phase 1, the evap monitor will bypass Phase 2 and go directly to Phase 3 and open the canister vent solenoid to release the vacuum. Then, it will proceed to Phase 4, close the canister vent solenoid and measure the vacuum that develops. If the vacuum exceeds approximately 4 " $H_2O$, a P1450 DTC will be set.

## Phase 2 - Vacuum hold and decay

Next, the vacuum is held for a calibrated time and the vacuum level is again recorded at the end of this time period. The starting and ending vacuum levels are checked to determine if the change in vacuum exceeds the vacuum bleed up criteria. Fuel Level Input and ambient air temperature are used to adjust the vacuum bleed-up criteria for the appropriate fuel tank vapor volume. Steady state conditions must be maintained throughout this bleed up portion of the test. The monitor will abort if there is an excessive change in load, fuel tank pressure or fuel level input since these are all indicators of impending or actual fuel slosh. If the monitor aborts, it will attempt to run again (up to 20 or more times). If the vacuum bleed-up criteria is not exceeded, the small leak test is considered a pass. If the vacuum bleed-up criteria is exceeded on three successive monitoring events, a 0.040 " dia. leak is likely and a final vapor generation check is done to verify the leak, phases 3-4. Excessive vapor generation can cause a false MIL.

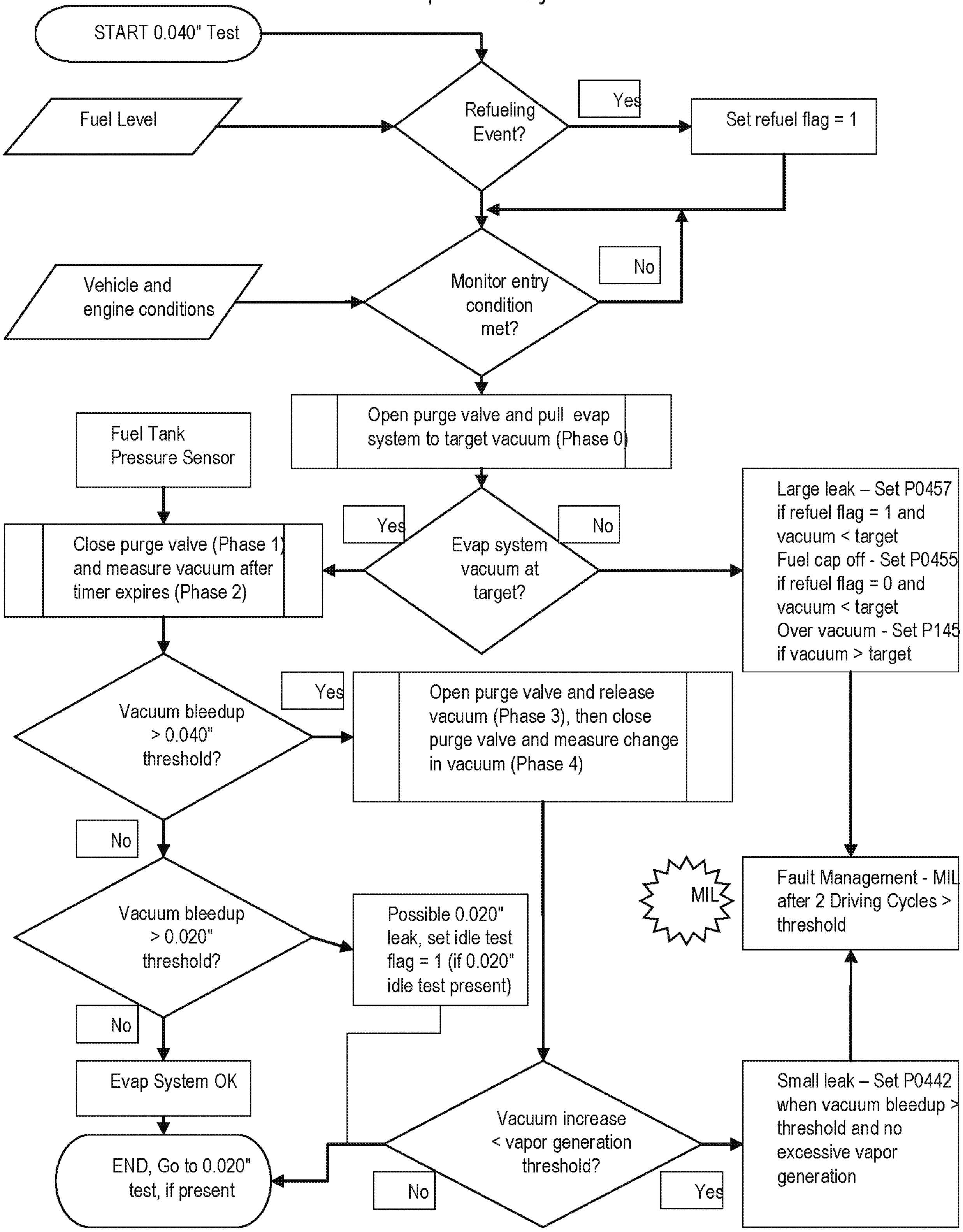
## Phase 3 - Vacuum release

This stage of the vapor generation check is done by opening the CVS and releasing any vacuum. The system will remain vented to atmosphere for approximately 30 - 60 seconds and then proceed to phase 4.

## Phase 4 - Vapor generation

This stage of the vapor generation check is done by closing the CVS and monitoring the pressure rise in the evaporative system. If the pressure rise due to vapor generation is below the threshold limit for absolute pressure and change in pressure, a P0442 DTC is stored.

## 0.040" Evaporative System Monitor



| 0.040" EVAP Monitor Operation: | |
|---|---|
| DTCs | P0455 (gross leak),<br>P1450 (excessive vacuum),<br>P0457 (gross leak, cap off),<br>P0442 (0.040" leak) |
| Monitor execution | once per driving cycle |
| Monitor Sequence | HO2S monitor completed and OK |
| Sensors/Components OK | MAF, IAT, VSS, ECT, CKP, TP, FTP, CPV, CVS |
| Monitoring Duration | 360 seconds (see disablement conditions below) |

| Typical 0.040" EVAP monitor entry conditions, Phases 0 through 4: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine off (soak) time OR<br>ECT at start – IAT at start <= 12 °F | 4 - 6 hours | |
| Time since engine start-up | 330 seconds | 1800 to 2700 seconds |
| Intake Air Temp | 40 °F | 95 - 100 °F |
| BARO (<8,000 ft altitude) | 22.0 " Hg | |
| Engine Load | 20% | 70% |
| Vehicle Speed | 40 mph | 90 mph |
| Purge Duty Cycle | 75% | 100% |
| Purge Flow | 0.05 lbm/min | 0.10 lbm/min |
| Fuel Fill Level | 15% | 85% |
| Fuel Tank Pressure Range | - 17 $H_2O$ | 1.5 $H_2O$ |

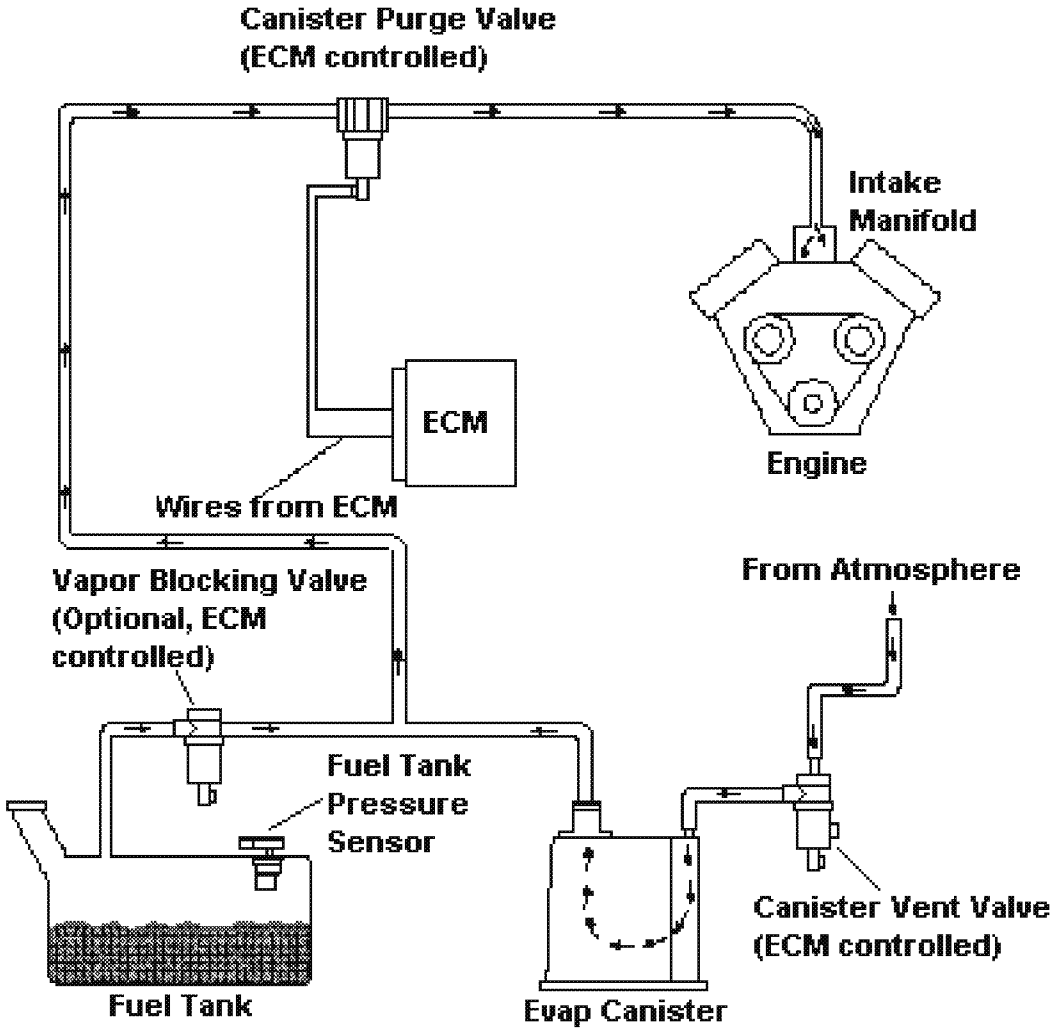
| Typical 0.040" EVAP abort (fuel slosh) conditions for Phase 2: |
|---|
| Change in load: > 30% |
| Change in tank pressure: > 1 " $H_2O$ |
| Change in fuel fill level: > 15% |
| Number of aborts: > 255 |

| Typical 0.040 EVAP monitor malfunction thresholds: |
|---|
| P1450 (Excessive vacuum): < -8.0 in $H_2O$ over a 30 second evaluation time or > -4. in $H_2O$ vapor generation<br>P0455 (Gross leak): > -8.0 in $H_2O$ over a 30 second evaluation time.<br>P0457 (Gross leak, cap off): > -8.0 in $H_2O$ over a 30 second evaluation time after a refueling event.<br>P0442 (0.040" leak): > 2.5 in $H_2O$ bleed-up over a 15 second evaluation time at 75% fuel fill. (Note: bleed-up and evaluation times vary as a function of fuel fill level and ambient air temperature)<br>P0442 vapor generation limit: < 2.5 in $H_2O$ over a 120 second evaluation time |

| J1979 Evaporative System Mode $06 Data | | | |
|---|---|---|---|
| Test ID | Comp ID | Description | Units |
| $3A | $80 | Phase 0 end pressure result and test limits (data for P1450 – excessive vacuum) | Pa |
| $3A | $81 | Phase 4 vapor generation minimum change in pressure and test limits (data for P1450, CPV stuck open) | Pa |
| $3A | $82 | Phase 0 end pressure result and test limits (data for P0455/P0457 – gross leak/cap off) | Pa |
| $3B | $80 | Phase 2 0.040" cruise leak check vacuum bleed-up and test limits (data for P0442 – 0.040" leak) | Pa |
| Note: Default values (0.0 Pa) will be displayed for all the above TIDs if the evap monitor has never completed. Each TID is associated with a particular DTC. The TID for the appropriate DTC will be updated based on the current or last driving cycle, default values will be displayed for any phases that have not completed. | | | |

## EVAP System Monitor - 0.020" dia. Engine Off Natural Vacuum

Some vehicles that meet enhanced evaporative requirements utilize an engine off natural vacuum (EONV) evaporative system integrity check that tests for 0.020" dia. leaks while the engine is off and the ignition key is off. The evap system integrity check uses a Fuel Tank Pressure Transducer (FTPT), a Canister Vent Solenoid (CVS) and Fuel Level Input (FLI) to find 0.020" diameter evap system leaks.




The Ideal Gas Law (PV=mRT) defines a proportional relationship between the Pressure and Temperature of a gas that is contained in a fixed Volume. Therefore, if a sealed container experiences a drop in temperature it will also experience a drop in pressure. In a vehicle, this happens when a sealed evaporative system cools after the engine has been run, or if it experiences a drop in temperature due to external environmental effects. This natural vacuum can be used to perform the leak check, hence the name Engine Off Natural Vacuum (EONV). Condensation of fuel vapor during cooling can add to the vacuum produced by the Ideal Gas Law.

In contrast to the vacuum produced by drops in temperature, an additional factor can be heat transfer to the evaporative system from the exhaust system immediately after key-off. Heat transfer from the exhaust at key-off aided by fuel vaporization may produce a positive pressure shortly after key-off, which can also be used for leak detection.

The EONV system is used to perform only the 0.020" leak check while 0.040" dia. leaks and larger (including fuel cap off) will continue to be detected by the conventional vacuum leak monitor performed during engine running conditions.

Ford's EONV implementation for California and Green State applications uses a separate, stay-alive microprocessor in the PCM to process the required inputs and outputs while the rest of the PCM is not powered and the ignition key is off. The stay-alive microprocessor draws substantially less battery current than the PCM; therefore, powering only the stay-alive micro during engine-off conditions extends vehicle battery life and allows the EONV monitor to run more often. The PCM is the only difference between California/Green State and Federal vehicles.

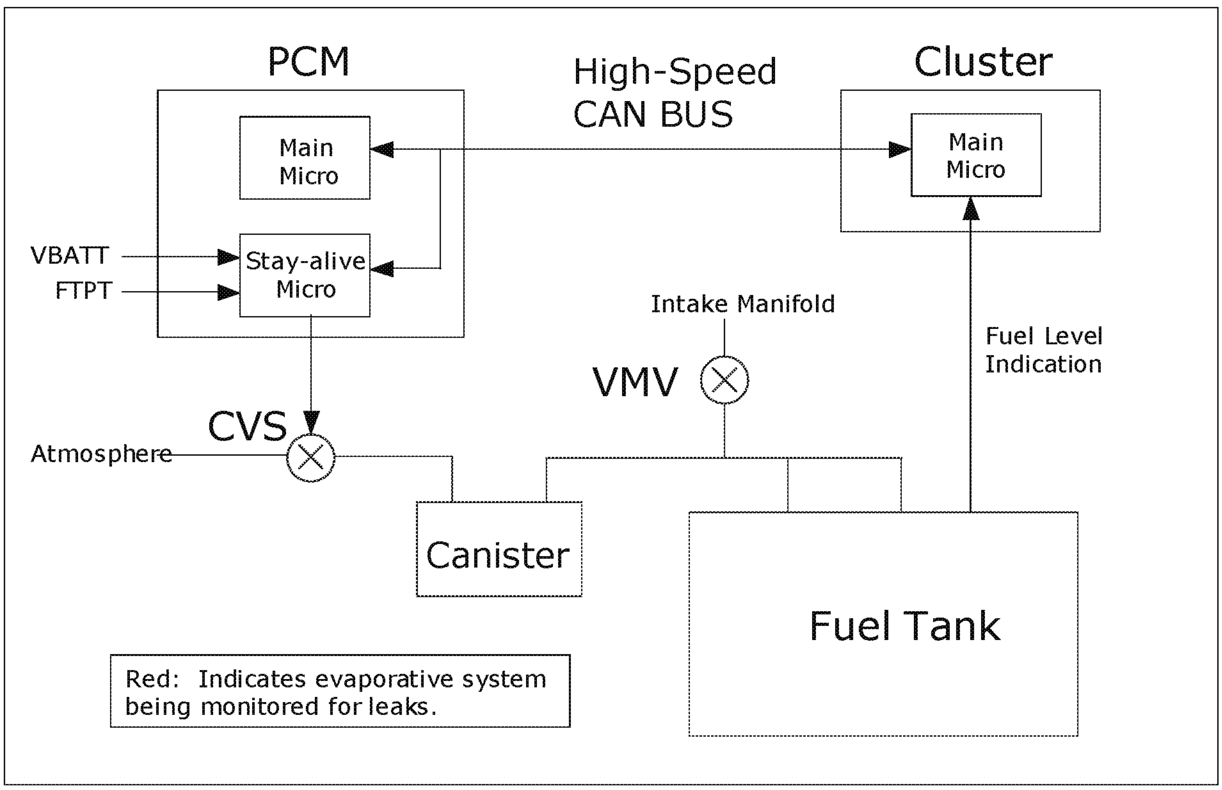
Inputs to EONV Microprocessor

- Fuel Tank Pressure
- Battery Voltage

Outputs from EONV Microprocessor

- Canister Vent Solenoid
- 0.020" leak data

# MY2005 EONV System Hardware Design



## Phase 0- Stabilization Phase

The purpose of the Stabilization Phase is to allow tank pressure to stabilize after vehicle shutdown (i.e. ignition in the OFF position). During this phase, the Canister Vent Solenoid (CVS) is open, thus allowing the pressure in the fuel tank to stabilize at atmospheric pressure. The duration of the Stabilization Phase is approximately 2 minutes. A fuel volatility check is performed just prior to its completion.

The fuel volatility check measures tank pressure and will abort the test if more than 1.5 "$H_20$ is observed in the tank. Because the CVS is open during this test, it would take a good deal of fuel vaporization to produce this level of pressure on a vented system. As an example, this condition may occur when a customer performs a long drive with highly volatile, winter fuel on a 100-deg F day. Note: This feature is not used in most applications.

If the fuel volatility check passes, a Fuel Tank Pressure Transducer (FTPT) offset correction factor is learned as the last step of this phase. This correction factor is applied to pressure measurements in the next phase to improve FTPT accuracy.

## Phase 1 – First Test Phase

At the start of this phase, the CVS is commanded shut, thus sealing up the entire evaporative system. If the system is sufficiently sealed, a positive pressure or vacuum will occur during depending on whether the tank temperature change is positive or negative. Other effects such as fuel vaporization and condensation within the fuel tank will also determine the polarity of the pressure. As the leak size increases, the ability to develop a positive pressure or vacuum diminishes. With a 0.020" leak, there may be no measurable positive pressure or vacuum at all depending on test conditions.

During this phase, tank pressure is continuously measured and compared to calibrated detection thresholds (both positive pressure and vacuum) that are based on fuel level and ambient temperature. If either the pressure or vacuum threshold is exceeded, the test will be considered a pass, and the monitor will proceed to "Phase 4 – Test Complete". If a positive plateau occurs in tank pressure without exceeding the pass threshold, the monitor will progress to "Phase 2 – Transition Phase". If a vacuum occurs, the monitor will remain in Phase 1 until the test times out after 45 minutes have elapsed since key-off, or the pass threshold for vacuum is exceeded. In either case, the monitor will transition to "Phase 4 – Test Complete."

## Phase 2- Transition Phase

This phase will occur if a positive pressure plateau occurred in Phase 1 without the positive pass threshold being exceeded. At the start of the Transition Phase, the CVS is opened and the evaporative system is allowed to stabilize. The Transition Phase lasts approximately 2 minutes, and a new FTPT offset correction is learned just prior to its completion. The monitor will then progress to "Phase 3 – Second Test Phase".

Note: This phase is termed the Transition Phase because there is a chance that a vacuum will be seen in the next phase if a positive pressure plateau occurred in Phase 1. The reason for this is that a positive plateau may be coincident with vapor temperature starting to decrease, which is favorable for developing a vacuum in the fuel tank. This is not always the case, and it is possible to see a positive pressure in Phase 3 as well.

## Phase 3- Second Test Phase

Upon completion of the Transition Phase, the CVS is commanded shut and the FTPT is monitored for any positive pressure or vacuum that develops. As with "Phase 1 – First Test Phase", if either the positive pressure or vacuum pass threshold is exceeded, the test is considered a pass and proceeds to "Phase 4 – Test Complete". Also, if the test times out after 45 minutes have elapsed since key-off, the test will be considered a fail (i.e. leak detected) and will also proceed to "Phase 4 – Test Complete".

## Phase 4 – Test Complete

In this phase, the EONV test is considered complete for this key-off cycle. The resultant peak pressure and peak vacuum are stored along with total test time and other information. This information is sent to the main microprocessor via CAN at the next engine start. During this phase, the CVS is commanded open and the electrical components performing the EONV test are shutdown to prevent any further power consumption.

## Test Aborts

During the EONV test, several parameters are monitored to abort the EONV test under certain conditions. The primary abort conditions are instantaneous changes in tank pressure and fuel level. They are used to detect refuel events and rapidly open the CVS upon detection of them. A list of abort conditions is given below.

## Post-2009 Model Year Fault Filtering

To increase the IUMP (rate-based) numerator once per monitor completion, the fault filtering logic for EONV was revised. The logic incorporates several important CARB requirements. These are:

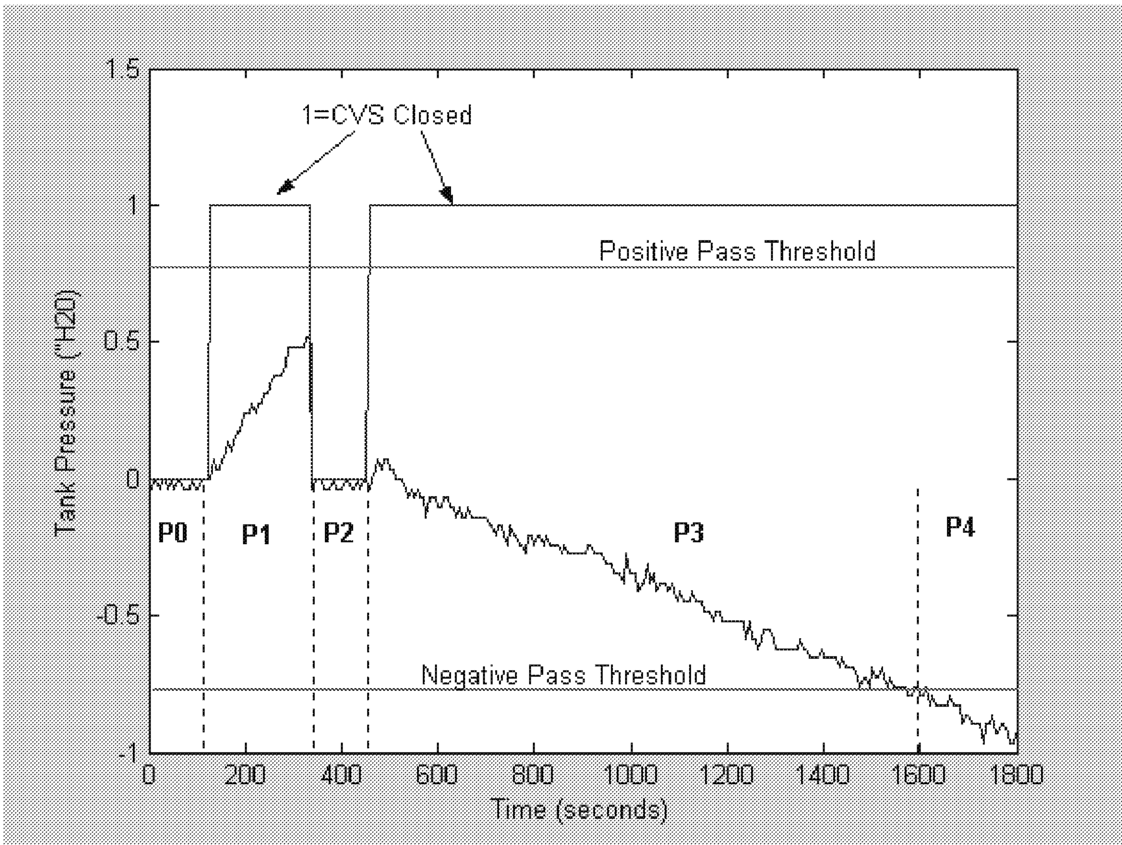
- Fast Initial Response (FIR): The first 4 tests after a battery disconnect or code clear will process unfiltered data to quickly indicate a fault. The FIR will use a 2-trip MIL. This will help the service technician determine that a fault has been fixed.

- Step-change Logic (SCL): The logic will detect an abrupt change from a no-fault condition to a fault condition. The SCL will be active after the 4th EONV test and will also use a 2-trip MIL. This will illuminate the MIL when a fault is instantaneously induced.

- Normal EWMA (NORM): This is the normal mode of operation and uses an Exponentially Weighted Moving Average (EWMA) to filter the EONV test data. It is employed after the 4th EONV test and will illuminate a MIL during the drive cycle where the EWMA value exceeds the fault threshold. (1 trip MIL). The recommended filter/time constant will produce filtering comparable to a previously-described 5-test average.

If there is a failure using any of the fault filtering logic shown above, a P0456 DTC will be set.

**Phases of EONV Test**



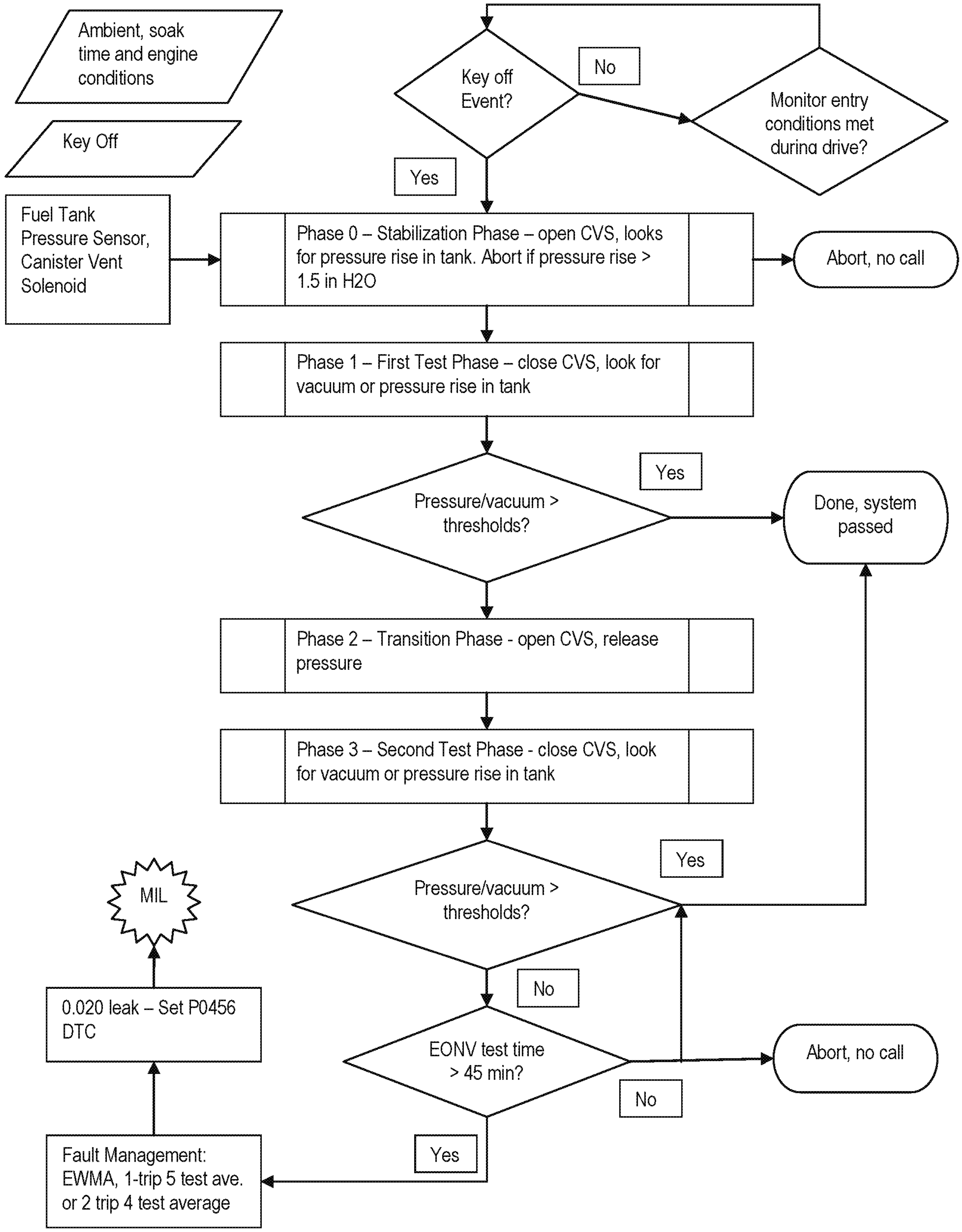

P0 = Phase 0, Stabilization Phase – With CVS open, Tank Pressure is allowed to stabilize. A fuel volatility test is performed and FTPT offset correction is learned if volatility test passes.

P1 = Phase 1, First Test Phase – CVS is closed and pressure peaks below positive pass threshold sending test to Phase 2. If the positive pass threshold were exceeded, the test would have completed and a pass would have been recorded.

P2 = Phase 2, Transition Phase – CVS is opened and a second stabilization phase occurs. A second FTPT offset is learned during this time.

P3 = Phase 3, Second Test Phase – CVS is closed again and a vacuum develops that eventually exceeds the negative pass threshold. When this occurs, the test proceeds to Phase 4, test complete.

P4 = Phase 4, Test Compete – CVS opens (not pictured in above data file), results are recorded, and stay-alive electronics shutdown.






ED_002078G_00001212-00053

| 0.020" EONV EVAP Monitor Operation: | |
|---|---|
| DTCs | P0456 (0.020" leak)<br>P260F (Evaporative System Monitoring Processor Performance) |
| Monitor execution | Once per key-off when entry conditions are met during drive. Monitor will run up to 2 times per day, or 90 cumulative minutes per day (whichever comes first) |
| Monitor Sequence | none |
| Sensors/Components OK | EONV Processor, Canister Vent Solenoid, Fuel Tank Pressure Sensor, Fuel Level Input, Vapor Management Valve, CAN communication link |
| Monitoring Duration | 45 minutes in key-off state if fault present. Tests will likely complete quicker if no fault is present. |

| Typical 0.020" EONV EVAP monitor entry conditions: | | |
|---|---|---|
| Entry conditions to allow EONV test (prior to key off) | Minimum | Maximum |
| Engine off (soak) time | 3.5 - 6 hours | |
| OR | | |
| Inferred soak criteria met: - (ECT at start – IAT at start ) | | 12 deg F |
| Inferred soak criteria met – ECT at start | 35 deg F | 105 deg F |
| Inferred soak criteria met - minimum engine off soak time | 0 sec | |
| Time since engine start-up to allow EONV test | 20 minutes | 90 minutes |
| Ambient Temperature at start-up | 40 $^{o}$F | 95 $^{o}$F |
| Battery Voltage to start EONV test | 11 volts | |
| Number of completed EONV tests in 24hr cycle | | 6 |
| Cumulative test time in 24hr cycle | | 90 minutes |
| Fuel level | 15% | 85% |
| ECU time since power-up to allow EONV test | 180 seconds | |
| Flex fuel inference complete | Learned | |
| BARO (<8,000 ft altitude) | 22.0 " Hg | |
| Summation of air mass since start ensures that vehicle has been operated off idle (function of ambient temperature). | 7500 to 15000 lbm/min | |
| Ratio of drive time to (drive + soak) time. (This allows for the driver to key-off for a short time without losing the initial soak condition.) | 0.8 | |

| Typical 0.020" EONV EVAP key-off abort conditions: |
|---|
| Tank pressure at key-off > 1.5" $H_20$ during stabilization phase (indicates excessive vapor) |
| Tank pressure not stabilized for tank pressure offset determination |
| Rapid change in tank pressure > 0.5"$H_20$ (used for refuel/slosh detection) |
| Rapid change in fuel level > 5% (used for refuel/slosh detection) |
| Battery voltage < 11 Volts |
| Rapid change in battery voltage > 1 Volt |
| Loss of CAN network |
| Canister Vent Solenoid fault detected |
| Driver turns key-on |

| Typical 0.020 EONV EVAP monitor malfunction thresholds: |
|---|
| P0456 (0.020" leak): < 0.75 in $H_2O$ pressure build and<br>< 0.50 in $H_2O$ vacuum build over a 45 minute maximum evaluation time<br><br>Note: EONV monitor can be calibrated to illuminate the MIL after two malfunctions (an average of four key-off EONV tests, eight runs in all) or after a single malfunction (an average of five key-off EONV tests, five runs in all), or using EWMA with Fast Initial Response and Step Change Logic. Most new 2006 MY and later vehicles will use the five-run approach, most new 2009 MY and later use the EWMA approach. |

| J1979 EONV EVAP monitor Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Comp ID | Description | Units |
| $3C | $81 | EONV Positive Pressure Test Result and Limits (data for P0456) | Pa |
| $3C | $82 | EONV Negative Pressure (Vacuum) Test Result and Limits(data for P0456) | Pa |
| $3C | $83 | Normalized Average of Multiple EONV Tests Results and Limits (where 0 = pass, 1 = fail) (data for P0456) | unitless |
| Note: Default values (0.0) will be displayed for all the above TIDs if the evap monitor has never completed. The appropriate TID will be updated based on the current or last driving cycle, default values will be displayed for any phases that have not completed. | | | |

## EVAP System Monitor Component Checks

Additional malfunctions that are identified as part of the evaporative system integrity check are as follows:

The **Canister Purge Valve (CPV)** output circuit is checked for opens and shorts (P0443)

Note that a stuck closed CPV generates a P0455, a leaking or stuck open CPV generates a P1450.

| Canister Purge Valve Check Operation: | |
|---|---|
| DTCs | P0443 – Evaporative Emission System Purge Control Valve "A" Circuit |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to obtain smart driver status |

| Typical Canister Purge Valve check malfunction thresholds: |
|---|
| P0443 (CPV): open/shorted at 0 or 100% duty cycle |

The **Canister Vent Solenoid** output circuit is checked for opens and shorts (P0446), a stuck closed CVS generates a P1450, a leaking or stuck open CVS generates a P0455.

| Canister Vent Solenoid Check Operation: | |
|---|---|
| DTCs | P0446 – Canister Vent Solenoid Circuit |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to obtain smart driver status |

| Typical Canister Vent Solenoid check malfunction thresholds: |
|---|
| P0446 (Canister Vent Solenoid Circuit): open/shorted |

The **Evap Switching Valve** (EVAPSV) output circuit is checked for opens and shorts (P2418).

| **Evap Switching Valve Check Operation:** | |
|---|---|
| DTCs | P2418 - Evap Switching Valve Circuit |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to obtain smart driver status |

| **Evap Switching Valve check malfunction thresholds:** |
|---|
| P2418 (Evap Switching Valve Circuit): open/shorted |

The **Fuel Tank Pressure Sensor** input circuit is checked for out of range values (P0452 short, P0453 open), noisy readings (P0454 noisy) and an offset (P0451 offset).

Note that an open power input circuit or stuck check valve generates a P1450.

| **Fuel Tank Pressure Sensor Transfer Function** | | |
|---|---|---|
| FTP volts = [ Vref * ( 0.14167 * Tank Pressure) + 2.6250 ] / 5.00 | | |
| Volts | A/D Counts in PCM | Fuel Tank Pressure, Inches $H_2O$ |
| 0.100 | 20 | -17.82 |
| 0.500 | 102 | -15.0 |
| 1.208 | 247 | -10.0 |
| 2.625 | 464 | 0 |
| 3.475. | 712 | 6.0 |
| 4.750 | 973 | 15.0 |
| 4.90 | 1004 | 16.06 |

| **Fuel Tank Pressure Sensor Check Operation:** | |
|---|---|
| DTCs | P0452 – Fuel Tank Pressure Sensor Circuit Low<br>P0453 – Fuel Tank Pressure Sensor Circuit High<br>P0454 – Fuel Tank Pressure Sensor Intermittent/Erratic (noisy) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds for electrical malfunctions, 10 seconds for noisy sensor test |

| Typical Fuel Tank Pressure Sensor check malfunction thresholds: |
|---|
| P0452 (Fuel Tank Pressure Sensor Circuit Low): < -17.82 in $H_2O$ |
| P0453 (Fuel Tank Pressure Sensor Circuit High): > 16.06 in $H_2O$ |
| P0454 (Fuel Tank Pressure Sensor Circuit Noisy): > open circuit, short circuit or > 4 in $H_2O$ change between samples, sampled every 100 msec |

| Fuel Tank Pressures Sensor Offset Check Operation | |
|---|---|
| DTCs | P0451 – Fuel Tank Pressure Sensor Range/Performance (offset) |
| Monitor execution | once per driving cycle |
| Monitor Sequence | No P0443 or P1450 DTCs |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 second |

| Typical Fuel Tank Pressure Sensor Offset Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Ignition key on, engine off, engine rpm | | 0 rpm |
| Purge Duty Cycle | | 0% |
| Engine off (soak) time | 4 - 6 hours | |
| Fuel Tank Pressure Sensor Variation during test | | 0.5 in $H_2O$ |
| Battery Voltage | 11.0 Volts | |

| Typical Fuel Tank Pressure Sensor Offset Check Malfunction Thresholds: |
|---|
| Fuel tank pressure at key on, engine off is 0.0 in $H_2O$ +/- 2.0 in $H_2O$ |

The **Fuel Level Input** is checked for out of range values (opens/ shorts). The FLI input is obtained from the serial data link from the instrument cluster. If the FLI signal is open or shorted, the appropriate DTC is set (P0462 circuit low and P0463 circuit high).

Vehicles with a "saddle tank" (a tank that wraps over the axle) have two fuel level senders. The FLI input is obtained from the serial data link from the instrument cluster. If the FLI signal is open or shorted, the appropriate DTC is set (P2067 circuit low and P2068 circuit high). A "jet pump" pumps fuel from the passive side of the saddle tank to the active side of the saddle tank where the main fuel pump supplies the engine with fuel. This means that the active side of the fuel tank typically has a high fuel level reading because it it constantly filled by the jet pump. For purposes of computing vehicle fuel level, the two FLI readings are averaged together into one signal that represents the combined fuel level.

Finally, the Fuel Level Input is checked for noisy readings. If the FLI input continues to change > 40% between samples, a P0461 DTC is set.

| Fuel Level Input Check Operation: | |
|---|---|
| DTCs | P0461 – Fuel Level Sensor A Circuit Noisy<br>P0462 – Fuel Level Sensor A Circuit Low<br>P0463 – Fuel Level Sensor A Circuit High<br>P2067 – Fuel Level Sensor B Circuit Low<br>P2068 – Fuel Level Sensor B Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 30 seconds for electrical malfunctions, |

| Typical Fuel Level Input check malfunction thresholds: |
|---|
| P0460 or P0462 (Fuel Level Input Circuit Low): < 5 ohms (< 1 A/D count) |
| P0460 or P0463 (Fuel Level Input Circuit High): > 200 ohms (>253 A/D counts) |
| P0461 (Fuel Level Input Noisy): > 40% change between samples, > 100 occurrences, sampled every 0.100 seconds |

The FLI signal is also checked to determine if it is stuck. "Fuel consumed" is continuously calculated based on PCM fuel pulsewidth summation as a percent of fuel tank capacity. (Fuel consumed and fuel gauge reading range are both stored in KAM and reset after a refueling event or DTC storage.) If the there is an insufficient corresponding change in fuel tank level, a P0460 DTC is set.

Different malfunction criteria are applied based on the range in which the fuel level sensor is stuck.

In the range between 15% and 85%, a 30% difference between fuel consumed and fuel used is typical. The actual value is based on the fuel economy of the vehicle and fuel tank capacity.

In the range below 15%, a 40% difference between fuel consumed and fuel used is typical. The actual value is based on reserve fuel in the fuel tank and the fuel economy of the vehicle.

In the range above 85%, a 60% difference between fuel consumed and fuel used is typical. The actual value is based on the overfill capacity of the fuel tank and the fuel economy of the vehicle. Note that some vehicles can be overfilled by over 6 gallons.

| **Fuel Level Input Stuck Check Operation:** | |
|---|---|
| DTCs | P0460 – Fuel Level Input Circuit Stuck |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | Between 15 and 85%, monitoring can take from100 to 120 miles to complete |

| **Typical Fuel Level Input Stuck check malfunction thresholds:** |
|---|
| P0460 (Fuel Level Input Stuck):<br>Fuel level stuck at greater than 90%: > 60% difference in calculated fuel tank capacity consumed versus change in fuel level input reading<br>Fuel level stuck at less than 10%: > 30% difference in calculated fuel tank capacity consumed versus change in fuel level input reading<br>Fuel level stuck between 10% and 90%: > 25% difference in calculated fuel tank capacity consumed versus change in fuel level input reading |

The **Evap Monitor Microprocessor** is checked for proper microprocessor operation or loss of CAN communication with the main microprocessor (P260F). Applies only if EONV is in separate microprocessor.

| **Evap Monitor Microprocessor Performance:** | |
|---|---|
| DTCs | P260F - Evap System Monitoring Processor Performance |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds |

## Evap Switching Valve (EVAPSV) Diagnostics

The Evap Switching Valve (EVAPSV) is included on HEV applications for 2009 Model Year. It is very similar to the Fuel Tank Isolation Valve (FTIV) used in previous model years. The Evap Switching Valve is also known as a Vapor Blocking Valve (VBV). The purpose of the EVAPSV is to isolate the fuel tank from the rest of the evaporative system so that the Canister Purge Valve (CPV) can purge more aggressively with minimal risk of purge vapor slugs being ingested into the intake.

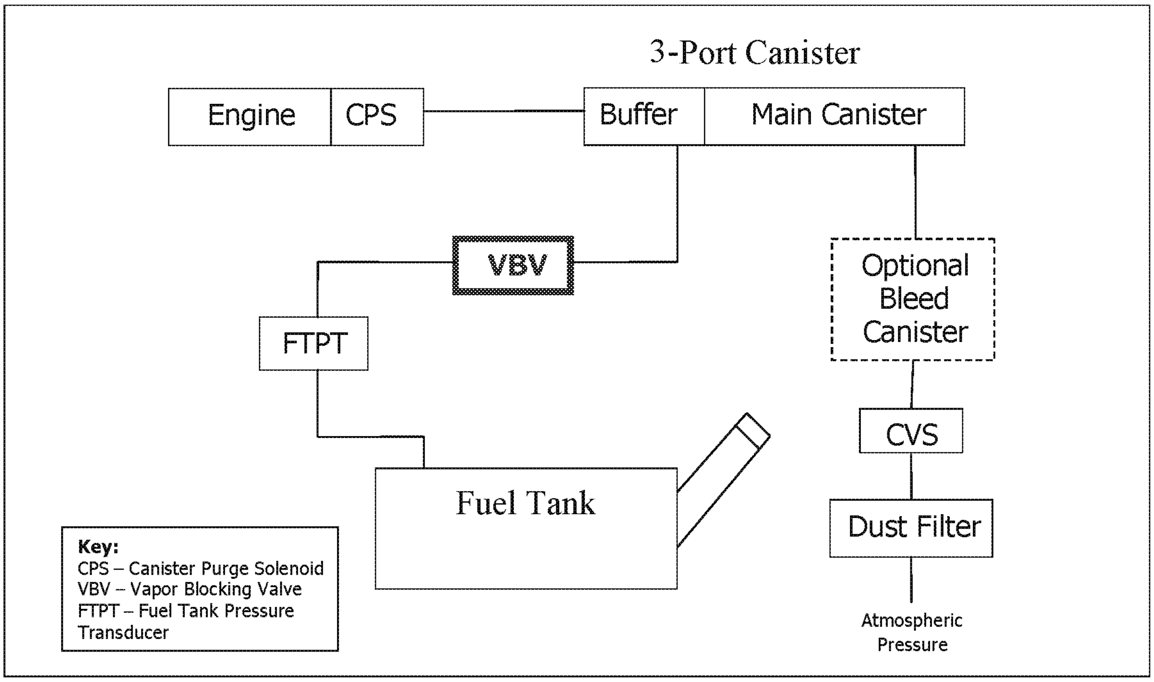
The EVAPSV is normally closed during engine operation, but may vent during a drive to relieve positive pressure. The exact pressure points at which the valve opens and closes are vehicle dependent. When the vehicle is in a key-off state, the EVAPSV is not powered and the valve is open.

The VBV circuit and functional diagnostics will set the following DTCs:

P2418 – EVAPSV circuit fault
P2450 – EVAPSV stuck open fault

The EVAPSV circuit diagnostics are very similar to that of the Canister Purge Valve (CPV) and Canister Vent Solenoid (CVS). See Evap System Monitor Component Checks below.

A diagram of an evaporative system with an EVAPSV (shown as a VBV) is shown below:



The Evaporative System monitor performs a functional check of the EVAPSV in Phase 3 of the evap monitor cruise tests if the 0.040" leak test passes. At the end of Phase 2, tank pressure will be in the range of -8 to -5 "H20 and the EVAPSV will be open. At the beginning of Phase 3, the EVAPSV is commanded closed and the CVS is commanded open. If the EVAPSV fails to close, there will be a rapid pressure loss in the fuel tank. If this pressure loss exceeds a calibrated threshold, a P2450 DTC is set. (Requires 2 or 3 failures in a row during a driving cycle (calibratable)). If the fault is present on a second driving cycle, the MIL will be illuminated.

| EVAP Switching Valve (EVAPSV) Monitor Operation: | |
|---|---|
| DTC | P2450 |
| Monitor execution | once per driving cycle |
| Monitor Sequence | Runs after evap 0.040" cruise test |
| Sensors/Components OK | MAF, IAT, VSS, ECT, CKP, TP, FTP, CPV, CVS |
| Monitoring Duration | 30 seconds (see disablement conditions below) |

| Typical EVAP Switching Valve (EVAPSV) monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| 0.040" Cruise Test completes | | |

| Typical EVAP Switching Valve (EVAPSV) abort conditions: |
|---|
| Change in fuel fill level: > 15% |

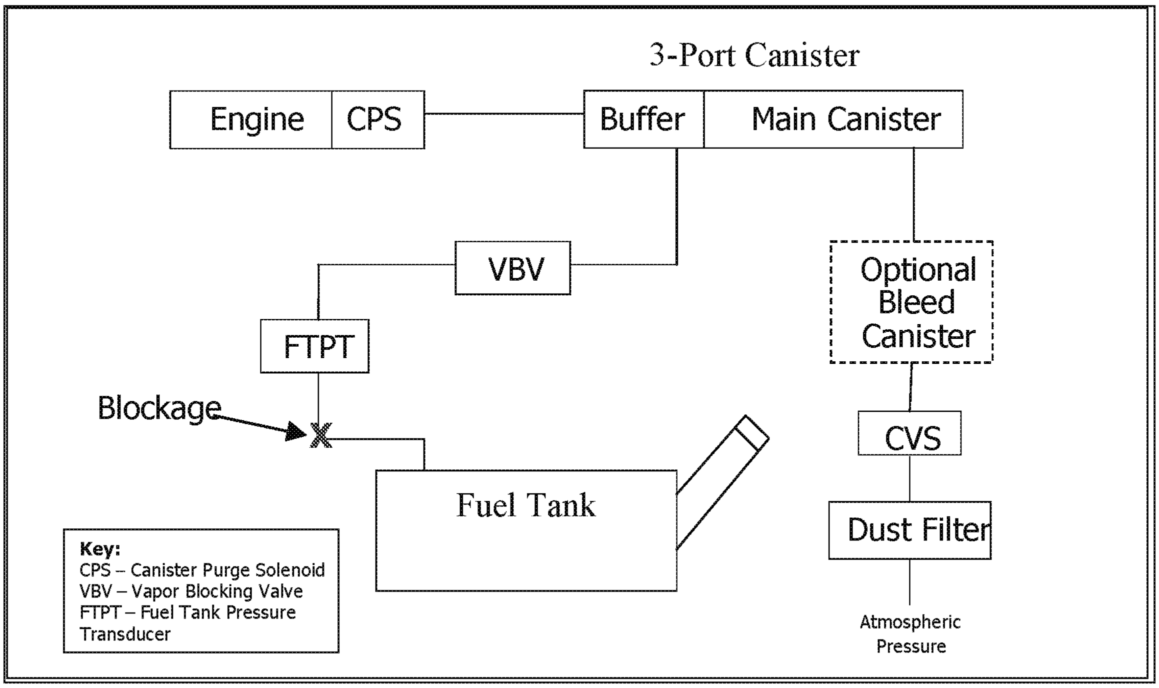
| Typical EVAP Switching Valve (EVAPSV) malfunction thresholds: |
|---|
| P2418: Presence of short, open, or intermittent fault for more than 5 seconds<br>P2450: Pressure loss > 3" $H_20$ during phase 3. |

| J1979 Evaporative System Mode $06 Data | | | |
|---|---|---|---|
| Test ID | Comp ID | Description | Units |
| $3D | $82 | Vapor blocking valve performance (P2450) | Pa |
| Note: Default values (0.0 Pa) will be displayed for all the above TIDs if the evap monitor has never completed. Each TID is associated with a particular DTC. The TID for the appropriate DTC will be updated based on the current or last driving cycle, default values will be displayed for any phases that have not completed. | | | |

## Blocked Purge Line Diagnostics

If an in-line Fuel Tank Pressure Transducer is used, it is possible for a blockage to occur between the Fuel Tank Pressure Transducer (FTPT) and fuel tank. If this occurs, the evap monitor would run and pass all leak check diagnostics even if there is a leak at the fuel cap. (The blockage will make the system look sealed despite the leak.). The blocked line diagnostic looks for a rapid drop in pressure during Phase 0 of the cruise test. This rapid pressure drop occurs because the Canister Purge Valve (CPV) applies a vacuum to just the canister and evap lines. Upon seeing an excessively fast pressure drop in Phase 0, the evap monitor will invoke a special execution of Phase 3 & 4 where a CPV pressure pulse is applied to the evap system. This pressure pulse is at a very low flow and short duration (0.5 -1.0 seconds) to avoid drivability issues. If this intrusive test fails, the Phase 0 test and the intrusive test are repeated 2 or 3 times prior to setting a P144A DTC.

Diagram of an evaporative system with a blockage is shown below:



| EVAP Blocked Line Monitor Operation: | |
|---|---|
| DTC | P144A |
| Monitor execution | once per driving cycle |
| Monitor Sequence | Runs during Phase 0 of evap 0.040" cruise test. Performs an intrusive test in Phases 3 & 4 to confirm a fault. |
| Sensors/Components OK | MAF, IAT, VSS, ECT, CKP, TP, FTP, CPV, CVS |
| Monitoring Duration | 30 seconds (see disablement conditions below) |

| Typical Blocked Line monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| General 0.040" Cruise Test conditions apply | | |
| Air mass high enough for intrusive portion of test | 1.5 (lb/min) | |
| Manifold vacuum high enough for intrusive portion of test | 5 "Hg | |
| Not in open loop fueling | | |
| CPV purging | | |

| Typical EVAP Blocked Line abort conditions: |
|---|
| All items cited under entry conditions apply. |

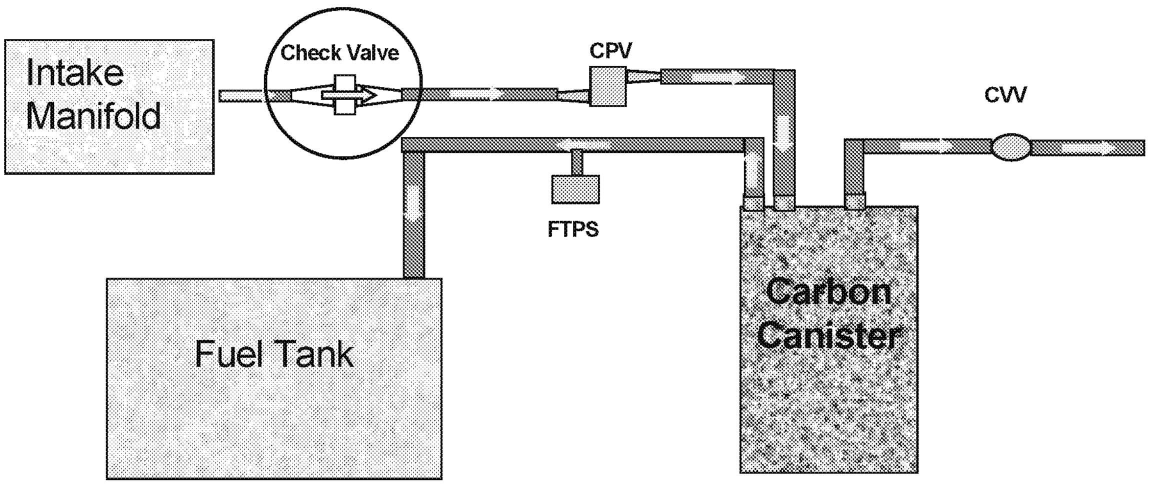
| Typical EVAP Blocked Line malfunction thresholds: |
|---|
| P144A: Phase 0 portion of test delta pressure < -5 "$H_20$/sec<br>P144A: Phase 3 & 4 (intrusive test) pressure response < -2 "$H_20$ |

| J1979 Evaporative System Mode $06 Data | | | |
|---|---|---|---|
| Test ID | Comp ID | Description | Units |
| $3D | $80 | Blocked Evap System Line - Screening test (P144A) | Pa/sec |
| $3D | $81 | Blocked Evap System Line - Fault confirmation test (P144A) | Pa |
| Note: Default values (0.0) will be displayed for all the above TIDs if the evap monitor has never completed. Each TID is associated with a particular DTC. The TID for the appropriate DTC will be updated based on the current or last driving cycle, default values will be displayed for any phases that have not completed. | | | |
| | | | |

## Single Path Purge Check Valve Diagnostics

Boosted applications use a mechanical check valve between the intake manifold and the Canister Purge Valve (CPV). The purpose of this check valve is to prevent reverse flow through the evaporative emissions system under boosted conditions. The check valve is a simple diaphragm type valve were the rubber diaphragm slides inside a cylinder and is pushed against a stop under boost closing off flow through the valve. While at atmosphere or under vacuum the valve is pulled off the stop allowing flow from the evaporative system to the intake manifold. The check valve diagnostic looks for a failed open, improperly installed, or missing valve that could result in intake manifold vapors being pushed back into the evaporative emissions system (see figure below). A failed check valve is detected if the rate of rise in Fuel Tank Pressure Sensor is greater than a calibratable threshold while the Canister Vent Valve is closed, Canister Purge Valve open, and the engine is boosted above a minimum level (under boost the system should be sealed if the check valve is operating properly). This condition will set DTC P144C.

Figure: System schematic showing the potential for reverse flow if the check valve is failed.



| Evaporative System Purge Check Valve Performance Diagnostic Operation: | |
|---|---|
| DTC | P144C - Evaporative Emission System Purge Check Valve Performance |
| Monitor execution | Once per driving cycle, during boosted operation |
| Monitor Sequence | None |
| Sensors/Components OK | ECT/CHT, IAT, MAP, CPV, CVV, FTPT, FLI, BARO, TIP |
| Monitoring Duration | 5 to 10 seconds depending on level of boost |

| Typical Evaporative System Purge Check Valve Performance Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Ambient temperature (IAT) | 40 ° F | 95 ° F |
| Battery Voltage | 11.0 Volts | |
| Fuel level | 15% | 85% |
| Engine Coolant Temperature (CHT/ECT) | 160 ° F | |
| Atmospheric Pressure (BARO) | 23” Hg | |
| Boost Pressure (MAP – BARO) | 4 to 8” Hg | |

| Typical Evaporative System Purge Check Valve Diagnostic malfunction thresholds: |
|---|
| Pressure Rise Rate (delta pressure / delta time) > 0.50 " $H_2O$/sec<br>Threshold is a function of fuel level with a range of 0.5 to 1.0 |

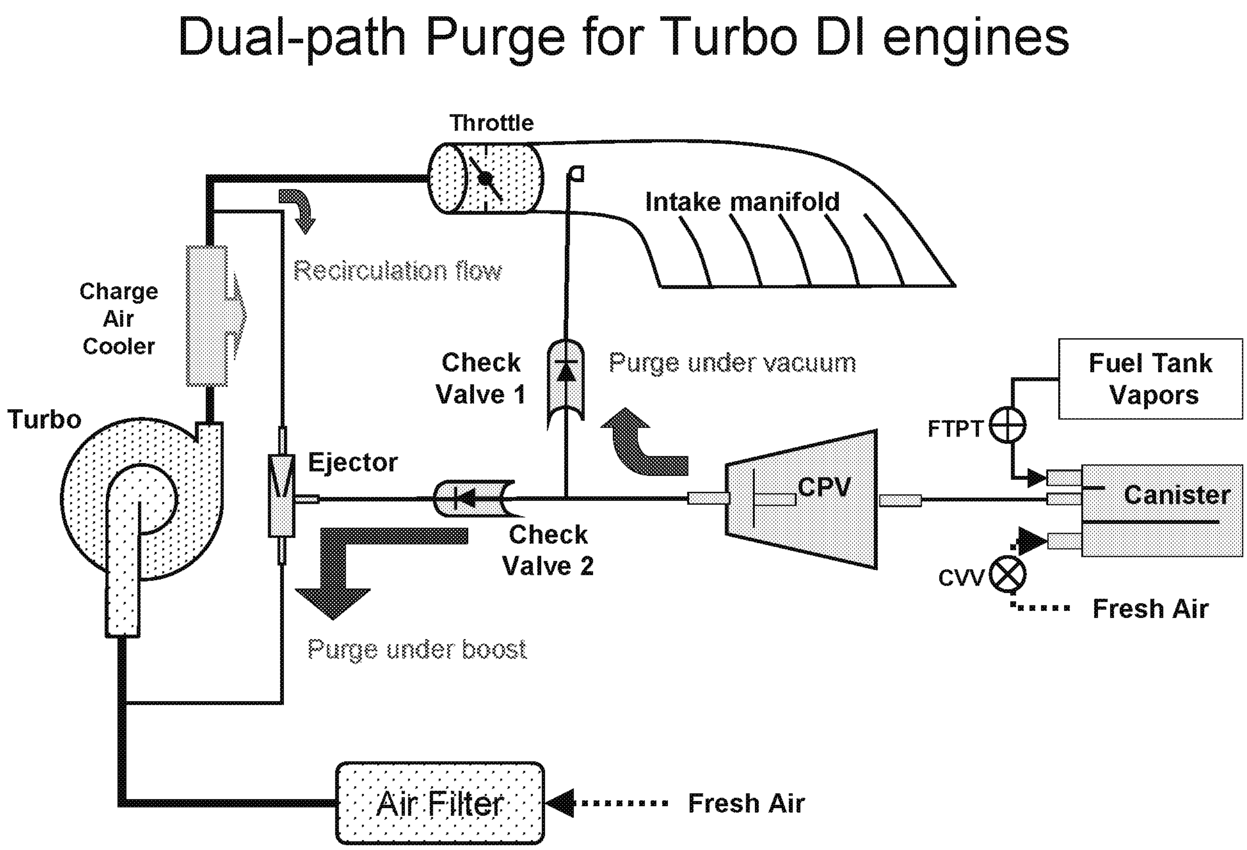
## Dual Path Purge Check Valve Diagnostics

Boosted applications that have a lower power-to-weight ratio use two purge flow paths to allow purge under boost conditions in addition to normal vacuum conditions.

Dual path purge applications use a mechanical check valve 1 (CV1) between the intake manifold and the Canister Purge Valve (CPV). During non-boosted conditions, purge vapors go through check valve 1 before entering the intake. The purpose of this check valve is to prevent reverse flow through the evaporative emissions system under boosted conditions. The check valve is a simple diaphragm type valve were the rubber diaphragm slides inside a cylinder and is pushed against a stop under boost closing off flow through the valve.

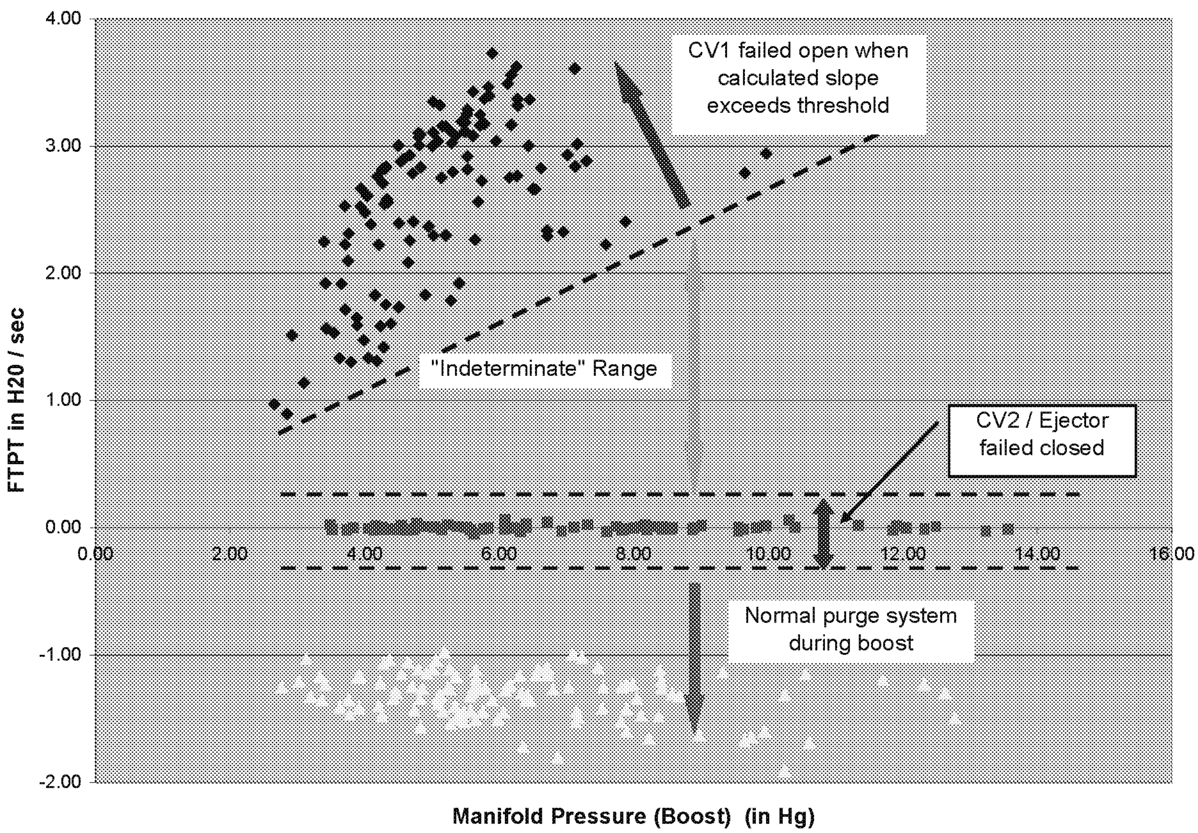
A second identical check valve 2 (CV2) is used to facilitate purging during boost. During boosted conditions, a venturi device, called an ejector, is used to generate the needed vacuum for purging. The purge vapors flow through CV2, the turbo charger, and the charge air cooler before entering the intake manifold.

The check valve diagnostic looks for a failed open CV1, a failed closed CV2, a failed ejector, an improperly installed CV1 or CV2, or missing CV1 that could result in intake manifold vapors being pushed back into the evaporative emissions system or lack of purge under boost.



A failed CV1 is detected if the rate of rise in Fuel Tank Pressure Sensor is greater than a calibratable threshold while the Canister Vent Valve is closed, Canister Purge Valve open, and the engine is boosted above a minimum level. Under boost, the system should be sealed if the check valve is operating properly. This condition will set DTC P144C.

A failed CV2 is detected if the rate of change of ejector generated vacuum is relatively flat within a threshold window during boosted conditions. This will set DTC P144C. Steep vacuum slopes for CV2 are indicative of good functioning valves. See the figure below for CV1/CV2 pass and fail ranges.



| Evaporative System Purge Check Valve Performance Diagnostic Operation: | |
|---|---|
| DTC | P144C - Evaporative Emission System Purge Check Valve Performance |
| Monitor execution | Once per driving cycle, during boosted operation |
| Monitor Sequence | None |
| Sensors/Components OK | ECT/CHT, IAT, MAP, CPV, CVV, FTPT, FLI, BARO, TIP, WASTEGATE |
| Monitoring Duration | 5 to 10 seconds depending on level of boost |

| Typical Evaporative System Purge Check Valve Performance Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Ambient air temperature | 40 ° F | 105 ° F |
| Battery Voltage | 11.0 Volts | |
| Fuel level | 15% | 90% |
| Engine Coolant Temperature | 160 ° F | |
| Atmospheric Pressure (BARO) | 23" Hg | |
| Boost Pressure (MAP – BARO) | 8" Hg | |

| Typical Evaporative System Purge Check Valve Diagnostic malfunction thresholds: |
|---|
| CV1- Pressure Rise Rate (delta pressure / delta time) > 1 " $H_2O$/sec<br>CV1- Threshold is a function of fuel level with a range of 1.5 to 2.6<br>CV2- Vacuum Rate (delta vacuum / delta time) >-0.4 and < 0.5 $H_2O$/sec<br>CV2- Threshold is a function of fuel level with a range of 0.5 to 0.7 for the upper band and -0.4 to -0.3 for the lower band |

# Fuel System Monitor

The adaptive fuel strategy uses O2 sensors for fuel feedback. The fuel equation includes short and long term fuel trim modifiers:

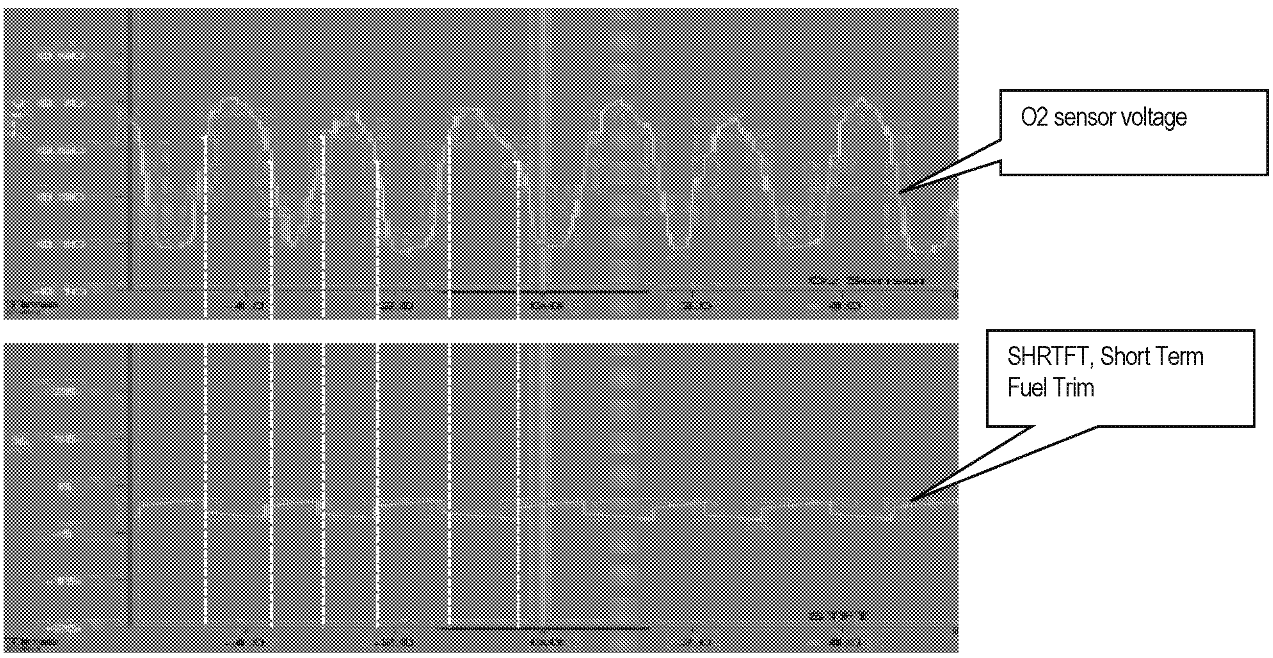
$$\text{FUEL MASS} = \frac{\text{AIR MASS} * \text{SHRTFT} * \text{LONGFT}}{\text{EQUIV\_RATIO} * 14.64}$$

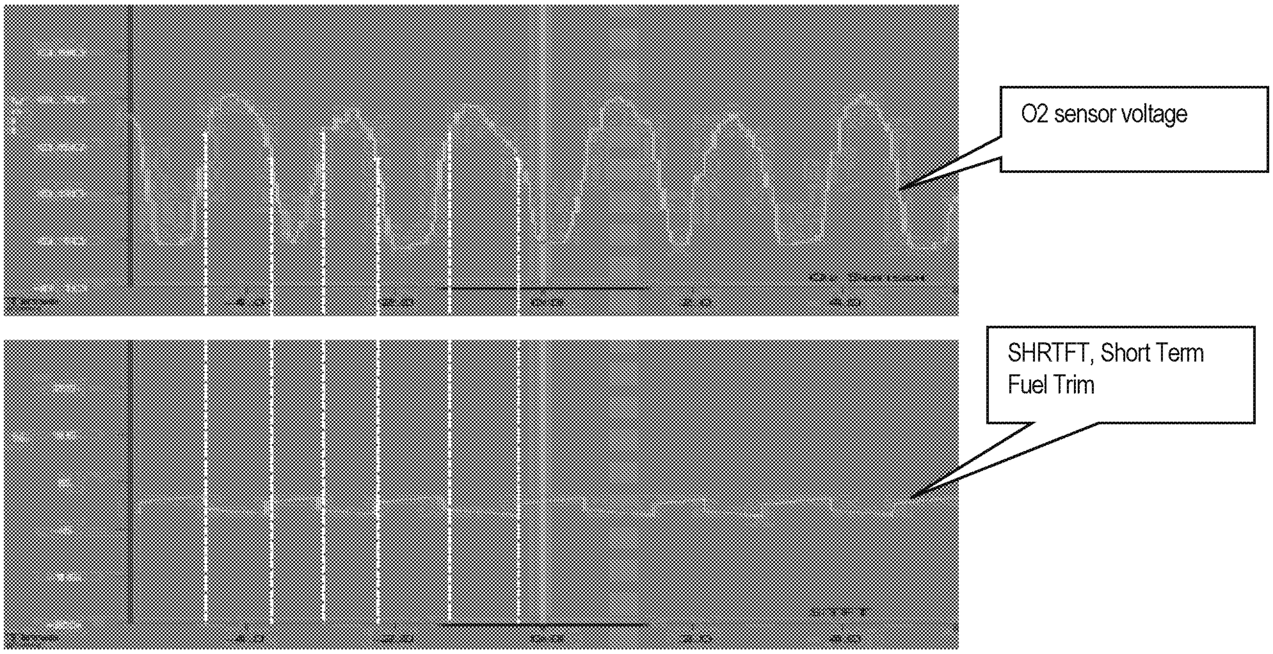
Where:

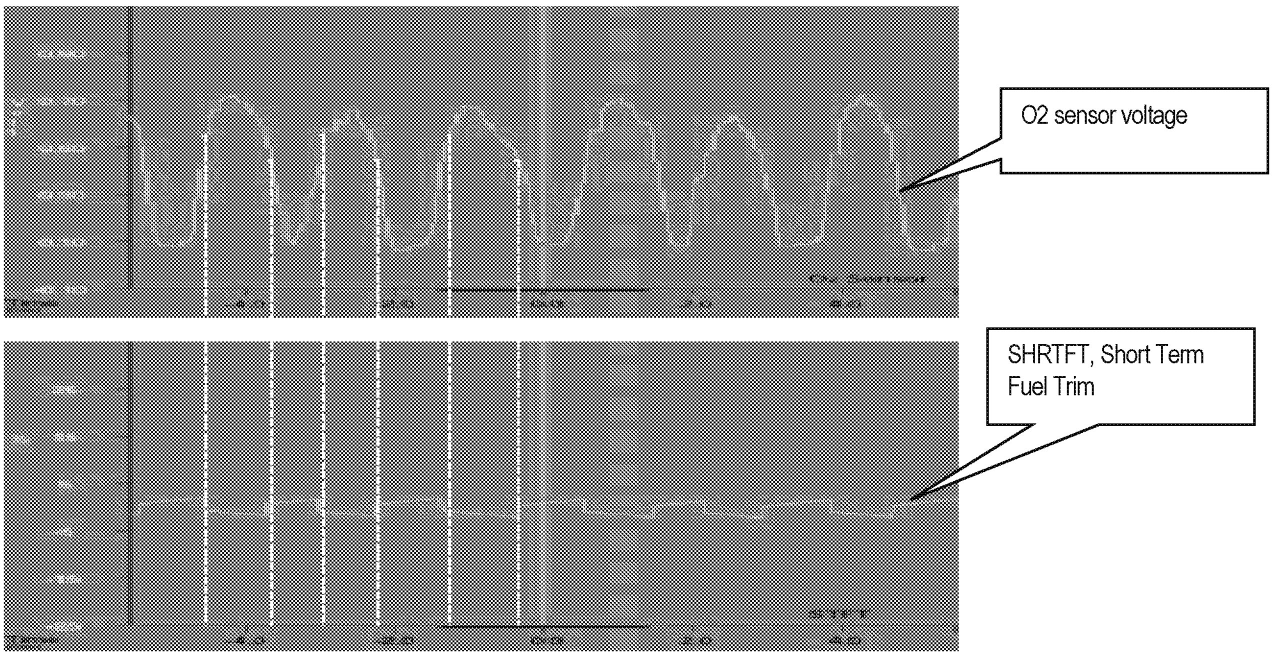
Fuel Mass = desired fuel mass
Air Mass = measured air mass, from MAF sensor
SHRTFT = Short Term Fuel Trim, calculated
LONGFT = Long Term Fuel Trim, learned table value, stored in Keep Alive Memory
EQUIV_RATIO = Desired equivalence ratio, 1.0 = stoich, > 1.0 is lean, < 1.0 is rich
14.64 = Stoichiometric ratio for gasoline

A conventional O2 sensor (not a wide-range sensor) can only indicate if the mixture is richer or leaner than stoichiometric. During closed loop operation, short term fuel trim values are calculated by the PCM using oxygen sensor inputs in order to maintain a stoichiometric air/fuel ratio. The PCM is constantly making adjustments to the short term fuel trim, which causes the oxygen sensor voltage to switch from rich to lean around the stoichiometric point. As long as the short term fuel trim is able to cause the oxygen sensor voltage to switch, a stoichiometric air/fuel ratio is maintained.

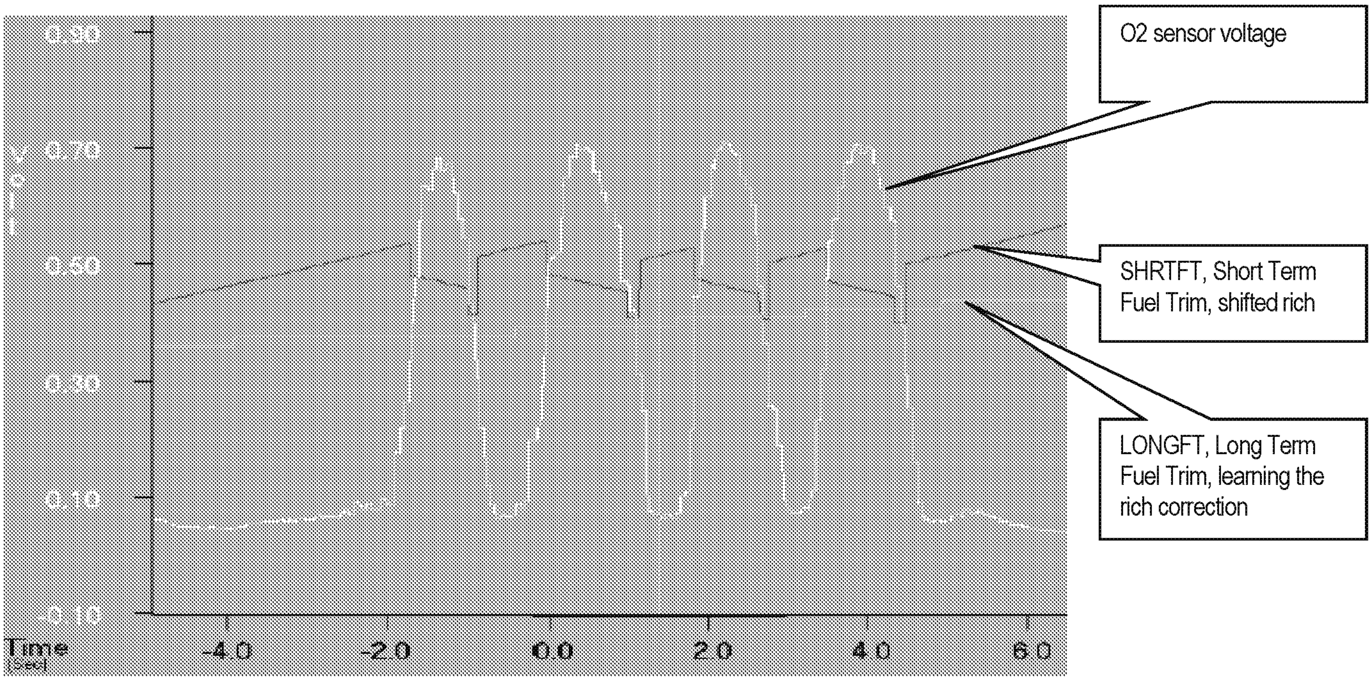
When initially entering closed loop fuel, SHRTFT starts 1.0 and begins adding or subtracting fuel in order to make the oxygen sensor switch from its current state. If the oxygen sensor signal sent to the PCM is greater than 0.45 volts, the PCM considers the mixture rich and SHRTFT shortens the injector pulse width. When the cylinder fires using the new injector pulse width, the exhaust contains more oxygen. Now when the exhaust passes the oxygen sensor, it causes the voltage to switch below 0.45 volts, the PCM considers the mixture lean, and SHRTFT lengthens the injector pulse width. This cycle continues as long as the fuel system is in closed loop operation.

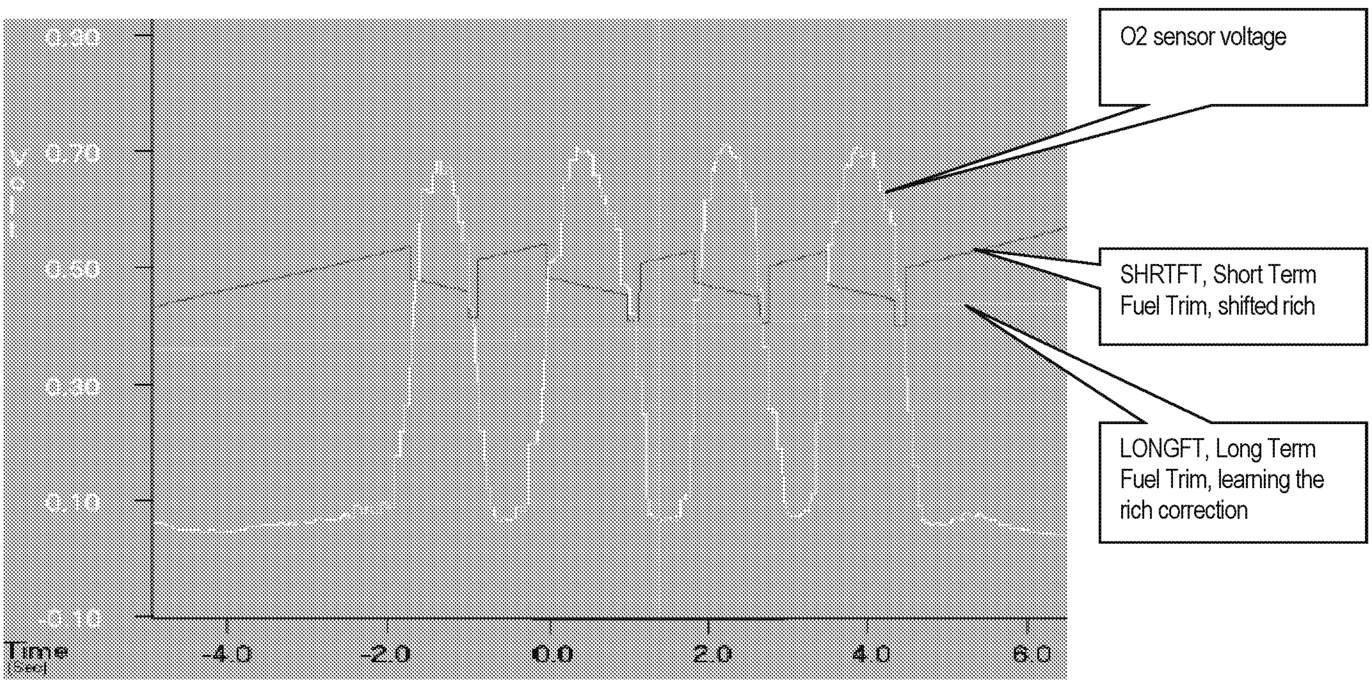



O2 sensor voltage
SHRTFT, Short Term Fuel Trim

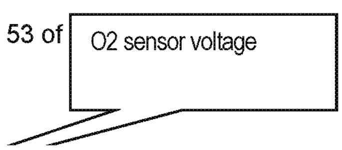

O2 sensor voltage
SHRTFT, Short Term Fuel Trim

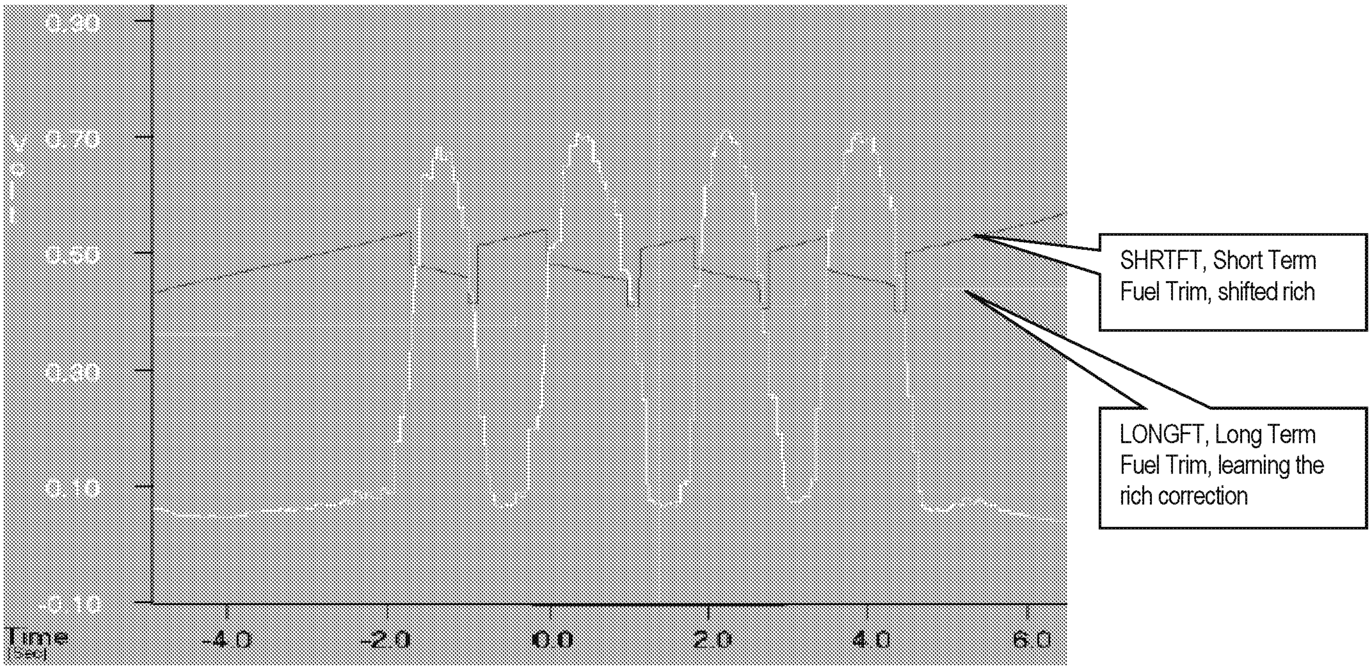
As fuel, air, or engine components age or otherwise change over the life of the vehicle, the adaptive fuel strategy learns deviations from stoichiometry while running in closed loop fuel. Corrections are only learned during closed loop operation, and are stored in the PCM as long term fuel trim values (LONGFT). They may be stored into an 8x10 rpm/load table or they may be stored as a function of air mass. LONGFT values are only learned when SHRTFT values cause the oxygen sensor to switch. If the average SHRTFT value remains above or below stoichiometry, the PCM “learns” a new LONGFT value, which allows the SHRTFT value to return to an average value near 1.0. LONGFT values are stored in Keep Alive Memory as a function of air mass. The LONGFT value displayed on the scan tool is the value being used for the current operating condition.





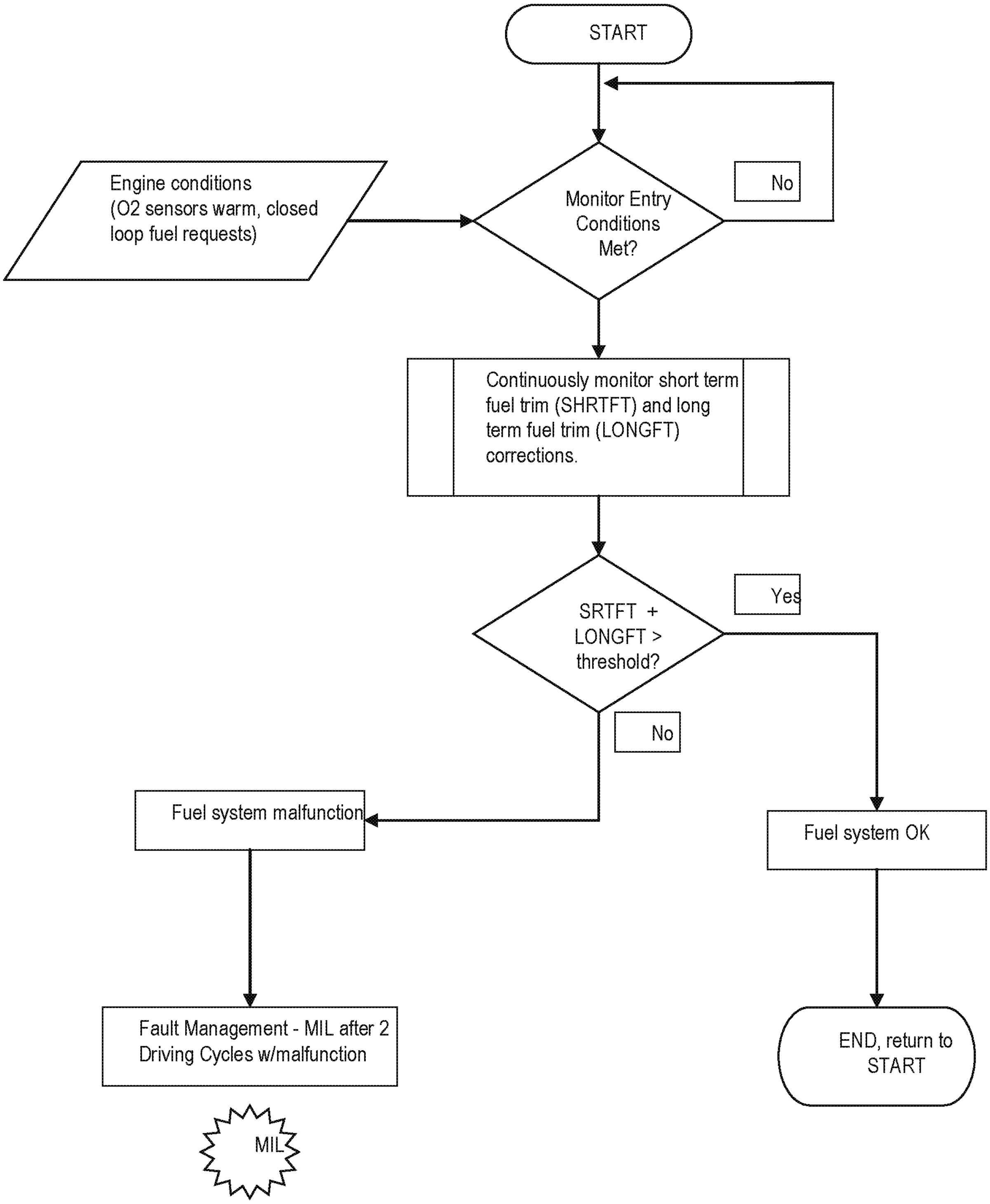






As components continue to change beyond normal limits or if a malfunction occurs, the long-term fuel trim values will reach a calibratable rich or lean limit where the adaptive fuel strategy is no longer allowed to compensate for additional fuel system changes. Long term fuel trim corrections at their limits, in conjunction with a calibratable deviation in short term fuel trim, indicate a rich or lean fuel system malfunction.

Note that in the PCM, both long and short-term fuel trim are multipliers in the fuel pulse width equation. Scan tools normally display fuel trim as percent adders. If there were no correction required, a scan tool would display 0% even though the PCM was actually using a multiplier of 1.0 in the fuel pulse width equation.

## Fuel System Monitor



| Fuel Monitor Operation: | |
|---|---|
| DTCs | P0171 Bank 1 Lean, P0174 Bank 2 Lean<br>P0172 Bank 1 Rich, P0175 Bank 2 Rich |
| Monitor execution | continuous while in closed loop fuel |
| Monitor Sequence | none |
| Sensors OK | Fuel Rail Pressure (if available), IAT, CHT/ECT, MAF, TP |
| Monitoring Duration | 2 seconds to register malfunction |

| Typical fuel monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Coolant Temp | 150 °F | 230 °F |
| Engine load | 12% | |
| Intake Air Temp | -30 °F | 150 °F |
| Air Mass Range | 0.75 lb/min | |
| Purge Duty Cycle | 0% | 0% |

| Typical fuel monitor malfunction thresholds: |
|---|
| Long Term Fuel Trim correction cell currently being utilized in conjunction with Short Term Fuel Trim:<br>Lean malfunction: LONGFT > 25%, SHRTFT > 5%<br>Rich malfunction: LONGFT < 25%, SHRTFT < 5% |

## FAOSC (Rear Fuel Trim) Monitor

As the front UEGO sensor ages and gets exposed to contaminants, it can develop a rich or lean bias in its transfer function. The rear bias control (also called FAOSC – Fore/Aft Oxygen Sensor Control) system is designed to compensate for any of these bias shifts (offsets) using the downstream HO2S sensor. The "FAOS" monitor looks for any bias shifts at the stoichiometric point of the front UEGO sensor lambda curve. If the UEGO has developed a bias beyond the point for which it can be compensated for, lean (P2096, P2098) or rich (P2097, P2099) fault codes will be set.

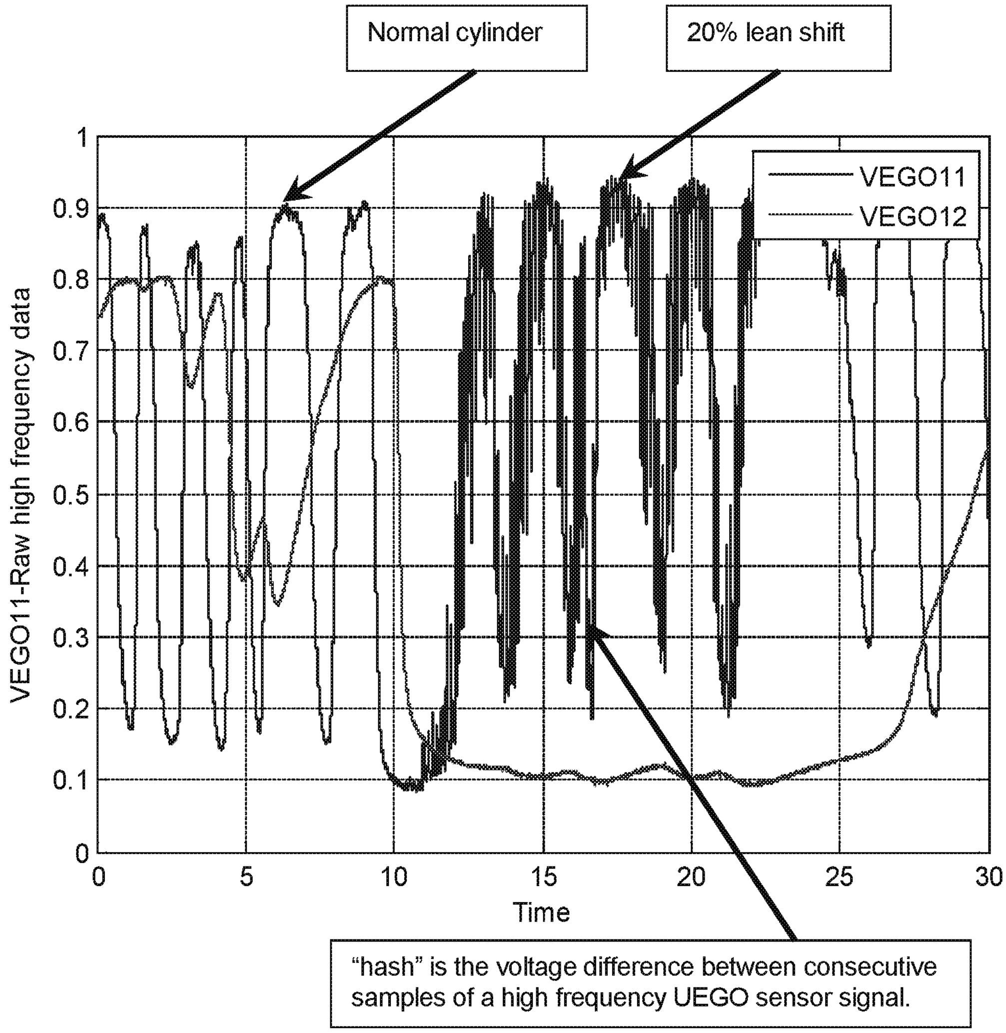
| UEGO "FAOS Monitor" Operation: | |
|---|---|
| DTCs | P2096 – Post catalyst fuel trim system too lean (Bank 1)<br>P2097 – Post catalyst fuel trim system too rich (Bank 1)<br>P2098 – Post catalyst fuel trim system too lean (Bank 2)<br>P2099 – Post catalyst fuel trim system too rich (Bank 2) |
| Monitor execution | Continuous while in closed loop fuel |
| Monitor Sequence | > 30 seconds time in lack of movement test, > 30 seconds time in lack of switch test |
| Sensors OK | ECT, IAT, MAF, MAP, VSS, TP, ETC, FRP, FVR, DPFE EGR, VCT, VMV/EVMV, CVS, CPV, EVAPSV, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, rear HO2S heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no UEGO circuit malfunction, no rear stream 2 HO2S circuit malfunction, no rear stream 2 HO2S functional DTCs, no rear stream 2 HO2S response rate malfunction. |
| Monitoring Duration | 5 seconds to register a malfunction |

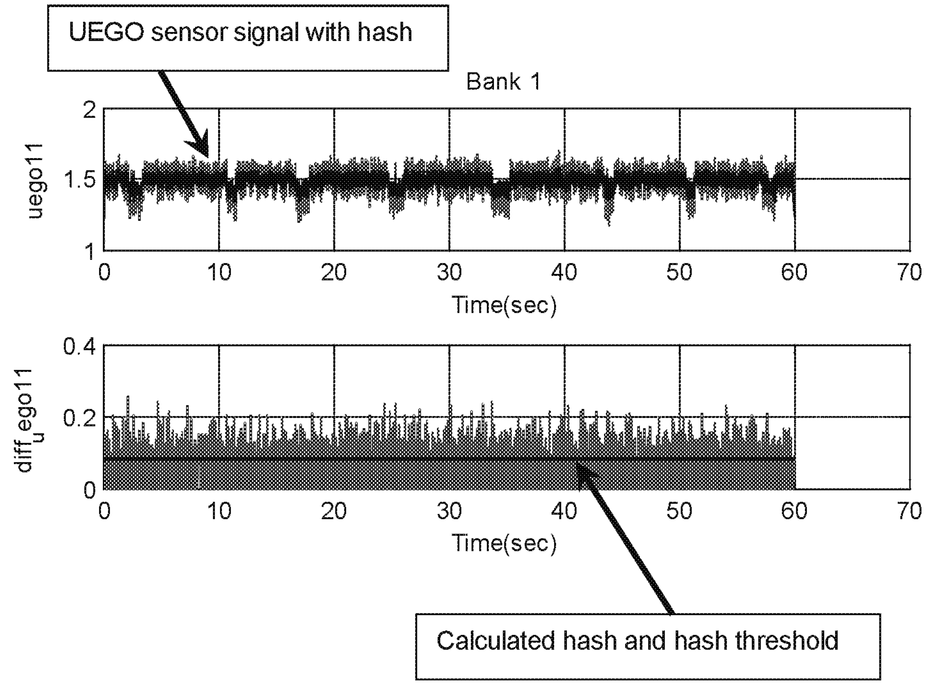
| Typical UEGO "FAOS Monitor" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed loop stoich fuel control | | |
| Time since engine start | 20 seconds | |
| Engine Coolant Temp | 160 $^{o}$F | 234 $^{o}$F |
| Time since entering closed loop fuel | 20 seconds | |
| Fuel Level | 15% | |
| Short Term Fuel Trim Range | -13% | 18% |
| Air mass range | 2 lbm/min | 8 lbm/min |
| Learning conditions stability time (based on air mass) | 15 seconds | |
| Injector fuel pulsewidth (not at minimum clip) | 650 usec | |
| Inferred HO2S 2 Heated Tip Temperature | 1100 $^{o}$F | |
| No excessive movement between currently utilized long term fuel trim cells (1 = complete change from one cell to adjacent cell) | | 0.5 |
| UEGO sensor within +/- 2 % from the fuel control target | | |
| UEGO ASIC not in recalibration mode | | |
| Stream1 UEGO response test not running | | |
| Intrusive UEGO catalyst monitor not running | | |
| Not performing intrusive UEGO Lack-of-Movement fuel control defib | | |
| No air passing through during valve overlap (scavenging). | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

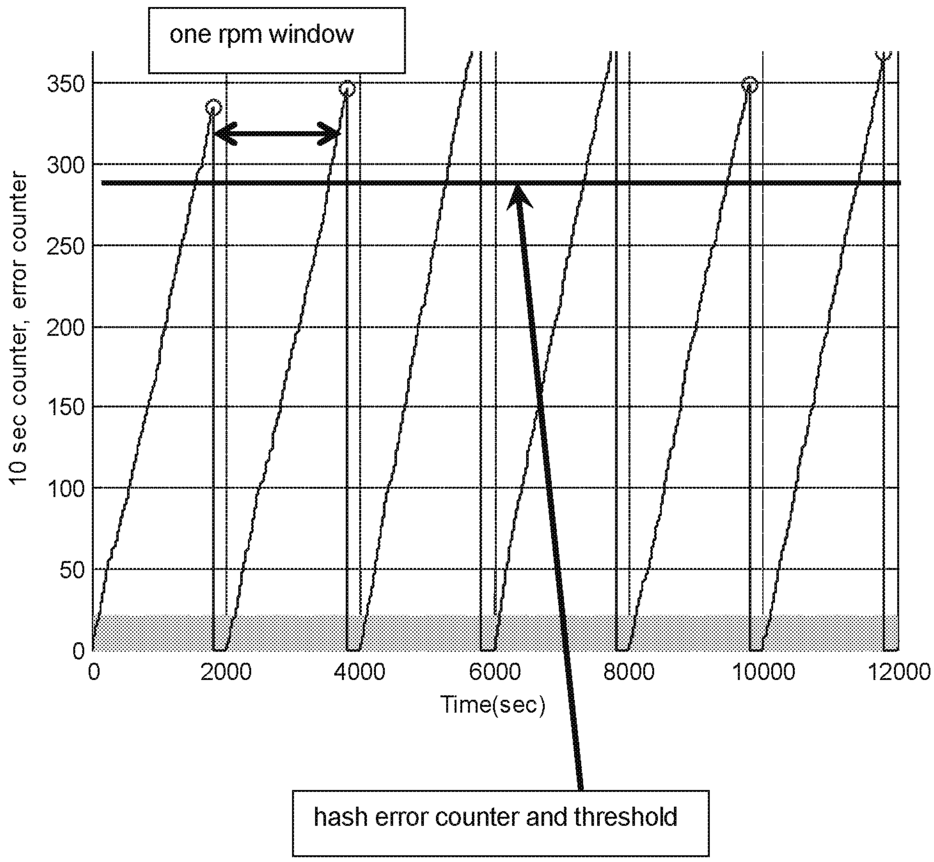
| Typical UEGO "FAOS Monitor" malfunction thresholds: |
|---|
| >= 5 seconds since reaching the FAOSC lean or rich limits while system bias maturity is met. |
| Lean malfunction: -0.083 rear bias trim limit |
| Rich malfunction: 0.087 rear bias trim limit |

### Air Fuel Ratio Imbalance Monitor

The Air Fuel Imbalance Monitor is designed to monitor the cylinder-to-cylinder air fuel imbalance per engine bank. When an Air Fuel (A/F) imbalance is present, the front UEGO signal becomes noisier. The monitor uses the high frequency component from the UEGO signal as an indicator of A/F imbalance. "Hash" is the difference between two consecutive front UEGO voltage samples. The UEGO signal is monitored continuously and a differential or "hash" value is continuously calculated. When the hash is below a threshold, it is indicative of normal operation. If the hash exceeds the threshold, an A/F imbalance is assumed which increments a hash error counter. The counter accumulates hash during series of calibratable rpm windows. Typically, a single window consists of 50 engine revolutions. A total rpm window counter calculates number of completed rpm windows. Monitor completion typically requires 30 rpm windows. When the monitor completes, an A/Fuel imbalance index is calculated. The monitor index is defined as the ratio of the failed rpm windows over the total rpm windows required to complete monitor. If the monitor imbalance ratio index exceeds the threshold value, an A/F imbalance DTC is set.




UEGO sensor signal with hash
Bank 1
uego11
2
1.5
1
0
10
20
30
40
50
60
70
Time(sec)
diff_uego11
0.4
0.2
0
Calculated hash and hash threshold


one rpm window
10 sec counter, error counter
350
300
250
200
150
100
50
0
2000
4000
6000
8000
10000
12000
Time(sec)
hash error counter and threshold

| Air Fuel Ratio Imbalance Operation | |
|---|---|
| DTCs | P219A – Bank 1 Air-Fuel Ratio Imbalance<br>P219B – Bank 2 Air-Fuel Ratio Imbalance |
| Monitor execution | Once per driving cycle during closed loop |
| Monitor Sequence | Monitor runs after fuel monitor has adapted |
| Sensors OK | ECT, IAT, MAF, VSS, TP, ETC, FRP, DPFE EGR, VCT, VMV/EVMV, CVS, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, rear HO2S heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no UEGO circuit malfunction, no rear stream 2 HO2S circuit malfunction, no rear stream 2 HO2S functional DTCs, no rear stream 2 HO2S response rate malfunction. |
| Monitoring Duration | Time to complete monitor ranges from 300 to 700 seconds |

| Air Fuel Ratio Imbalance entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop Fuel Control | | |
| Engine Air Mass | 2 lb/min | 10 lb/min |
| Engine RPM | 1250 rpm | 3000 rpm |
| Engine Load | 40% | 70% |
| Engine Coolant Temp | 150 °F | 235 °F |
| Intake Air Temp | 20 °F | 150 °F |
| Throttle Position Rate of Change | | 0.122 v/100 msec |
| Fuel percentage from purge | | 40% |
| Fuel Level | 15% | |
| Fuel monitor has adapted | | |
| No purge on/off transition | | |
| Fuel type leaning is complete (FFV only) | | |

| Air Fuel Ratio Imbalance malfunction thresholds: |
|---|
| Imbalance Ratio Bank 1 > .75<br>Imbalance Ratio Bank 2 > .75 |

| J1979 AFIMN MONITOR MODE $06 DATA | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| $81 | $80 | Bank 1 imbalance-ratio and max. limit (P219A/P219B) | unitless |
| $82 | $80 | Bank 2 imbalance-ratio and max. limit (P219A/P219B) | unitless |

## Flex Fuel Operation

Ford Motor Company is cooperating with the Department of Energy in providing customers with vehicles capable of using alcohol-blended fuels. These fuels are renewable and can lower some engine emission byproducts. The original 1993 Taurus vehicle hardware and calibration were designed for use on any combination of gasoline or methanol up to 85% methanol. Current flex fuel vehicles, however, are no longer designed for methanol, but are designed to be compatible with any combination of gasoline and ethanol, up to 85% ethanol.

This flexible fuel capability allows the vehicle to be usable in all regions of the country, even as the alcohol infrastructure is being built. Operation of a vehicle with the alcohol-blended fuels is intended to be transparent to the customer. Drivability, NVH, and other attributes are not notably different when using the alcohol-blended fuels. The higher octane of alcohol-blended fuels allows a small increase in power and performance (approximately 4%), but this is offset by the lower fuel economy (approximately 33%) due to the lower energy content. Cold starts with alcohol-blended fuels are somewhat more difficult than with gasoline due to the lower volatility of alcohol-blended fuels; 10% vaporization occurs at approximately 100 °F for gasoline vs. 160 °F for 85% ethanol. Ethanol requires approximately 37% more flow than gasoline due to a lower heating value (29.7 vs. 47.3 MJ/kg). Consequently, Flex Fuel vehicles require higher flow injectors than their gasoline counterparts. This results in a smaller fuel pulse widths with gasoline and makes the task of purging the canister more difficult during idles and decels.

In order to maintain proper fuel control, the PCM strategy needs to know the stoichiometric Air/Fuel Ratio for use in the fuel pulse width equation. On pre-2000 MY flex fuel vehicles, the percent alcohol in the fuel was determined by reading the output of the Flex fuel Sensor. The percent alcohol was stored in a register called Percent Methanol (PM). Although current alcohol-blended fuels only include ethanol, the percent methanol nomenclature has persisted. On 2000 MY and later vehicles, the Flex Fuel Sensor has been deleted and PM is inferred. The strategy to infer the correct A/F Ratio (AFR) relies on the oxygen sensor input to maintain stoichiometry after vehicle refueling occurs.

The relationship between PM and AFR is shown in the table below.

| Stoich Air Fuel Ratio = 14.64 - 5.64 * PM | |
|---|---|
| PM (percent alcohol) | Stoichiometric AFR |
| 0.00 (100 % gasoline) | 14.64 |
| 0.05 | 14.36 |
| 0.10 (standard gasoline) | 14.08 |
| 0.15 | 13.79 |
| 0.20 | 13.51 |
| 0.25 | 13.23 |
| 0.30 | 12.95 |
| 0.35 | 12.67 |
| 0.40 | 12.38 |
| 0.45 | 12.10 |
| 0.50 | 11.82 |
| 0.55 | 11.54 |
| 0.60 | 11.26 |
| 0.65 | 10.97 |
| 0.70 | 10.69 |
| 0.75 | 10.41 |
| 0.80 | 10.13 |
| 0.85 (standard E85) | 9.85 |
| 0.90 | 9.56 |
| 0.95 | 9.28 |
| 1.00 (100% ethanol) | 9.00 |

The fuel level input is used to determine if a refueling event has occurred, either after the initial start or while the engine is running. If refueling event is detected (typically calibrated as a 10% increase in fuel level), the PCM tracks the "old" fuel being consumed by the engine. After a calibrated amount of "old" fuel has been consumed from the fuel lines, fuel rail, etc., the "new" fuel is assumed to have reached the engine. Normal long term fuel trim learning and purge control are temporarily disabled along with the evaporative system monitor and fuel system monitor to allow the composition of the fuel to be determined. The filtered value of short-term fuel trim is used during closed loop to adjust AFR in order to maintain stoichiometry. During learning, all changes in AFR are stored into the AFRMOD register. As updates are made to the AFRMOD register, the fuel composition register (PM) is updated and stored in Keep Alive Memory. Learning continues until the inference stabilizes with stabilized engine operating conditions. The PM inference and engine operating conditions are considered to have stabilized when all of the following conditions are satisfied:

- ECT indicates the engine has warmed up (typically 170 °F) or an ECT related fault is present.
- Enough "new" fuel has been consumed (typically 0.5 lb - vehicle dependant) to insure fuel is adequately mixed.
- The filtered value of short term fuel trim is in tight fuel control around stoichiometry, (typically +/- 2%) for at least 5 O2 sensor switches or AFRMOD is at a clip.
- The engine has been operated for a calibratable length of time, based on ECT temperature at start (typically 200 sec. at 40 °F and 30 sec at 200 °F) or an ECT related fault is present.
- The engine has been operating in closed loop fuel, with the brake off, within a calibratable (off-idle) air mass region (typically 2.4 to 8 lb/min) for 5 seconds, to minimize the effect of errors such as vacuum leaks.

Once the value of PM has stabilized (usually about 7 miles of driving), AFRMOD and PM are locked and deemed to be "mature." After PM is deemed "mature," normal fuel trim learning and purge control are re-enabled along with the fuel system monitor and evaporative system monitor. Any observed fueling errors from that point on are rolled into normal long term fuel trim (via adaptive fuel learning).

All remaining OBD-II monitors remain enabled unless AFR is observed to be changing. If AFR is changing, all monitors (except CCM and EGR) are disabled until the AFR stabilizes. This logic is same as was used for FFV applications that used a sensor. The AFR rate of change required to disable OBD-II monitor operation is typically 0.1 A/F (rate is based on the difference between a filtered value and the current value). For a fuel change from gasoline to E85 or vice versa, AFR typically stabilizes after 2 to 3 minutes on an FTP cycle.

If a large refueling event is detected (typically calibrated as a 40% to 50% increase in fuel level), the PCM strategy tries to assign the "new" fuel as gasoline or ethanol (E85) on the assumption that the only fuels available are either gasoline or E85. The strategy performs this fuel assignment to gasoline or ethanol (E85) only if the "old" and the "new" stabilized inferred fuel composition values are within a specified amount of each other (typically 5-10%), indicating that the fuel in the tank is the same as the fuel that was added and therefore must be either gasoline or ethanol (E85). If the "old" and "new" stabilized inferred fuel composition values are not near each other, the fuel added must be different from what was in the tank and the strategy retains the current inferred value of PM until the next refuel. By assigning the fuel to gasoline or ethanol (E85) in this manner, normal fuel system errors can be learned into normal long term fuel trip for proper fuel system error diagnosis.

After a battery disconnect or loss of Keep Alive Memory, the strategy will infer AFR immediately after going into closed loop fuel operation. A vehicle that previously had fuel system errors learned into long term fuel trim will infer incorrect values of AFR. After the value of AFR is determined, it is fixed until the next refueling event. If the next refueling event is performed with the same fuel (either E85 or gasoline), the value of AFR will not change. The fuel is then assigned to be E85 or gasoline as explained above. The long term fuel trim will again be a reliable indication of normal fuel system errors.

Only one large tank fill is required to assign the fuel as being either gasoline or ethanol, if the inferred AFR did not change significantly. If AFR did change significantly, several tank fills with the same fuel may be necessary to assign the fuel as gasoline or ethanol.

As the vast majority of vehicles are expected to be operated with gasoline, the initial value of AFR is set to gasoline. This is the starting point for the AFR after a battery disconnect and will allow for normal starting. Some vehicles may have E85 in the fuel tank after having a battery disconnect, and may not have a good start or drive away. The startability of alcohol-blended fuels at extreme cold temperatures (< 0 °F) is difficult under normal conditions; these vehicles may be required to be towed to a garage for starting if a battery disconnect occurs.

# Front HO2S Monitor

## Front HO2S Signal

The time between HO2S switches is monitored after vehicle startup when closed loop fuel has been requested, during closed loop fuel conditions and when open loop fuel has been requested due to an HO2S fault. Excessive time between switches with short term fuel trim at its limits (up to +/- 40%), or no switches since startup indicate a malfunction. Since "lack of switching" malfunctions can be caused by HO2S sensor malfunctions or by shifts in the fuel system, DTCs are stored that provide additional information for the "lack of switching" malfunction. Different DTCs indicate whether the sensor was always indicates lean/disconnected (P2195, P2197), or always indicates rich (P2196, P2198).

Characteristic Shift Downward (CSD) is a deviation from the normal positive voltage output of the HO2S signal to negative voltage output. During a full CSD, the HO2S signal shifts downward (negative) by 1 volt. CSD occurs when the reference chamber of the HO2S becomes contaminated, causing negative HO2S voltage to be generated. Even though CSD can occur in both front and rear HO2S signals, only the front HO2S are compensated for CSD. The CSD compensation algorithm must not be in the process of driving fuel to bring the HO2S out of CSD before running some of the HO2S monitors.

2005 MY and later vehicles monitor the HO2S signal for high voltage, in excess of 1.1 volts and store a (P0132, P0152) DTC. An over voltage condition is caused by a HO2S heater or battery power short to the HO2S signal line.

| HO2S "Lack of Switching" Operation: | |
|---|---|
| DTCs | P2195 - Lack of switching, sensor indicates lean, Bank 1<br>P2196 - Lack of switching, sensor indicates rich, Bank 1<br>P2197 - Lack of switching, sensor indicates lean, Bank 2<br>P2198 - Lack of switching, sensor indicates rich, Bank 2 |
| Monitor execution | continuous, from startup and while in closed loop fuel or open loop fuel due to HO2S fault |
| Monitor Sequence | None |
| Sensors OK | ECT, IAT, MAF, VSS, TP, ETC, FRP, DPFE EGR, VCT, VMV/EVMV, CVS, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, front HO2S heaters OK, no front HO2S over voltage |
| Monitoring Duration | 30 seconds to register a malfunction |

| Typical HO2S "Lack of Switching" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop or Open Loop Requested due to HO2S fault | | |
| Stream 1 HO2S not in CSD recovery mode | | |
| No fuel flow entering thru PCV during cold start when flashing off fuel in oil (for O2 Sensor Stuck Rich DTCs only) | | |
| Inferred Ambient Temperature | -40 $^{o}$F | |
| Time within entry conditions | 10 seconds | |
| Fuel Tank Pressure | | 10 in $H_2O$ |
| Fuel Level | 15% | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical HO2S "Lack of Switching" malfunction thresholds: |
|---|
| < 5 switches since startup for > 30 seconds in test conditions or > 30 seconds since last switch while closed loop fuel |

| HO2S "Over Voltage Test" Operation: | |
|---|---|
| DTCs | P0132 Over voltage, Bank 1<br>P0152 Over voltage, Bank 2 |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | front HO2S heaters OK |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical HO2S "Over Voltage Test" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Inferred Stream 1 HO2S temperature | 400 $^{o}$F | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical HO2S "Over Voltage Test" malfunction thresholds: |
|---|
| > 1.1 volts for 10 seconds for over voltage test |

The HO2S is also tested functionally. The response rate is evaluated by entering a special 1.5 Hz. square wave, fuel control routine. This routine drives the air/fuel ratio around stoichiometry at a calibratable frequency and magnitude, producing predictable oxygen sensor signal amplitude. A slow sensor will show reduced amplitude. Oxygen sensor signal amplitude below a minimum threshold indicates a slow sensor malfunction. (P0133 Bank 1, P0153 Bank 2). If the calibrated frequency was not obtained while running the test because of excessive purge vapors, etc., the test will be run again until the correct frequency is obtained.

| HO2S Response Rate Operation: | |
|---|---|
| DTCs | P0133 (slow response Bank 1)<br>P0153 (slow response Bank 2) |
| Monitor execution | once per driving cycle |
| Monitor Sequence | > 30 seconds time in lack of switch test |
| Sensors OK | ECT, IAT, MAF, VSS, TP, ETC, FRP, DPFE EGR, VCT, VMV/EVMV, CVS, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel system, no EVAP gross leak failure, no "lack of switching" malfunctions, front HO2S heaters OK no front HO2S over voltage |
| Monitoring Duration | 6 seconds |

| Typical HO2S response rate entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Stream 1 HO2S not in CSD recovery mode | | |
| Flex Fuel Composition not changing | | |
| Not in Phase 0 of Evaporative System Monitor | | |
| No Purge System reset | | |
| Purge intrusive test not running | | |
| Not performing CSER spark retard | | |
| Engine Coolant Temp | 150 $^{o}$F | 240 $^{o}$F |
| Intake Air Temp | | 140 $^{o}$F |
| Time since entering closed loop fuel | 10 seconds | |
| Inferred Catalyst Midbed Temperature | | 1600 $^{o}$F |
| Fuel Level | 15% | |
| Short Term Fuel Trim Range | -9% | 11% |
| Short Term Fuel Trim Absolute Change while in monitor | | 10% |
| Engine Load | 20% | 50% |
| Maximum change in engine load while in monitor | | 0.13 |
| Vehicle Speed | 30 mph | 80 mph |
| Maximum change in vehicle speed while in monitor | | 3 mph |
| Engine RPM | 1000 rpm | 2000 rpm |
| Maximum change in engine rpm while in monitor | | 150 rpm |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical HO2Sresponse rate malfunction thresholds: |
|---|
| Voltage amplitude: < 0.5 volts |

| J1979 Front HO2S Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| $01 | $80 | HO2S11 voltage amplitude and voltage threshold P0133/P0153) | Volts |
| $01 | $01 | H02S11 sensor switch-point voltage | Volts |
| $05 | $80 | HO2S21 voltage amplitude and voltage threshold P0133/P0153) | Volts |
| $05 | $01 | H02S21 sensor switch-point voltage | Volts |

## Front HO2S Heaters

The HO2S heaters are monitored for proper voltage and current. A HO2S heater voltage fault is determined by turning the heater on and off and looking for corresponding voltage change in the heater output driver circuit in the PCM.

A separate current-monitoring circuit monitors heater current once per driving cycle. The heater current is actually sampled three times. If the current value for two of the three samples falls below a calibratable threshold, the heater is assumed to be degraded or malfunctioning. (Multiple samples are taken for protection against noise on the heater current circuit.)

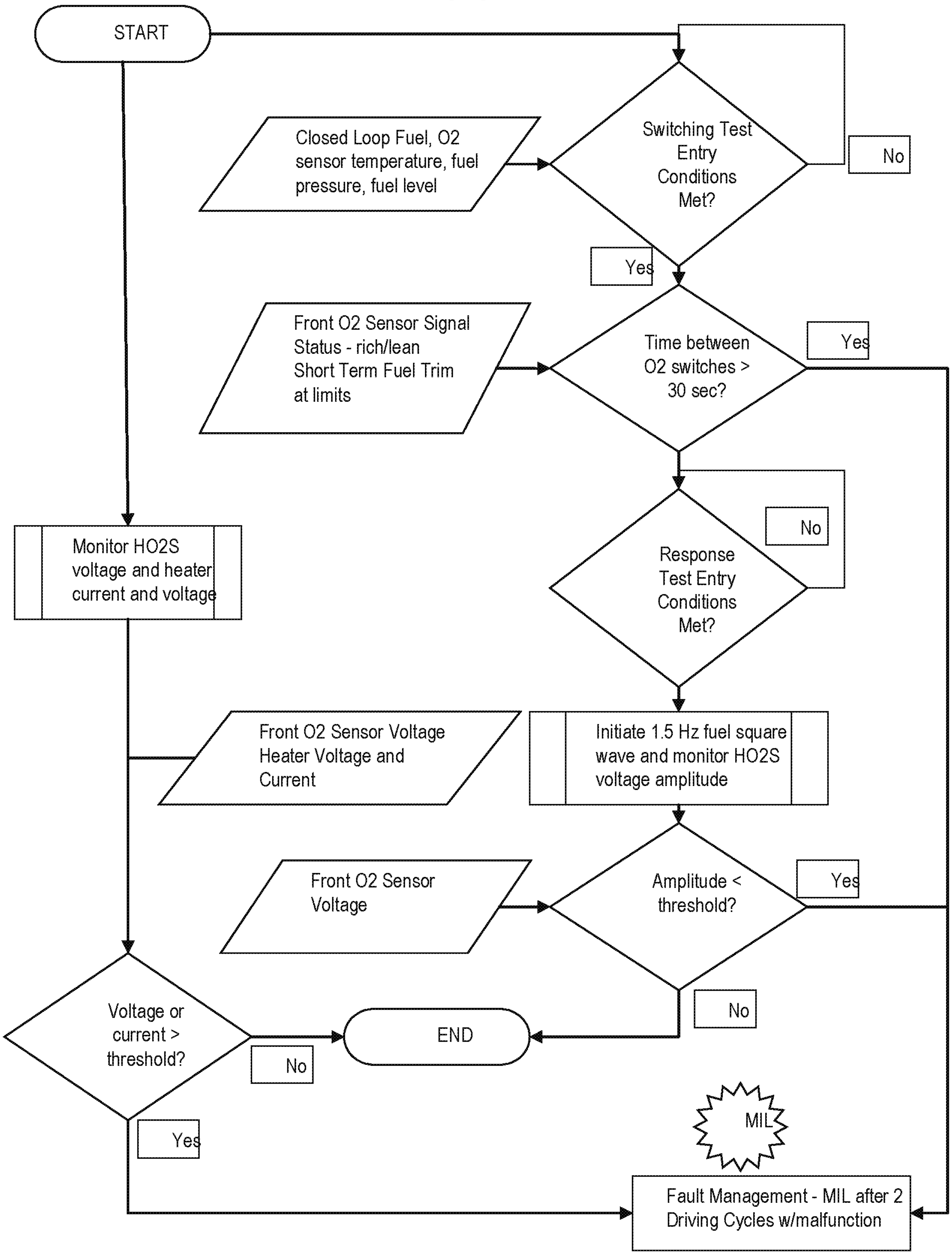
| HO2S Heater Monitor Operation: | |
|---|---|
| DTCs Sensor 1 | P0135 O2 Heater Circuit, Bank 1<br>P0155 O2 Heater Circuit, Bank 2<br>P0053 O2 Heater Resistance, Bank 1<br>P0059 O2 Heater Resistance, Bank 2 |
| Monitor execution | once per driving cycle for heater current, continuous for voltage monitoring |
| Monitor Sequence | Heater current monitor: Stream 1 HO2S/UEGO response test complete (2010 MY and earlier), Stream 2 and 3 HO2S functional tests complete (2010 MY and earlier), HO2S/UEGO heater voltage check complete |
| Sensors OK | Heater current monitor: no HO2S/UEGO heater voltage DTCs |
| Monitoring Duration | < 10 seconds for heater voltage check, < 5 seconds for heater current check |

| Typical HO2S heater monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Inferred HO2S 1 Temperature (heater voltage check only) | 150 $^{o}$F | 1250 $^{o}$F |
| Inferred HO2S 1 Temperature (heater current check only) | 250 $^{o}$F | 1250 $^{o}$F |
| HO2S 1/2/3 heater-on time (heater current check only) | 30 seconds | |
| Engine RPM (heater current check only) | | 5000 rpm |
| Battery Voltage (heater voltage check only) | 11.0 | 18.0 Volts |

| Typical HO2S heater check malfunction thresholds: | |
|---|---|
| Smart driver status indicated malfunction | |
| Number monitor retries allowed for malfunction > = 30 | |
| Heater current outside limits: | < 0.220 Amps or > 3 Amps, (NTK)<br>< 0.400 Amps or > 3 Amps, (Bosch)<br>< 0.465 Amps or > 3 Amps, (NTK Fast Light Off)<br>< 0.230 Amps or > 3 Amps, (Bosch Fast Light Off) |

| J1979 HO2S Heater Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | Units |
| $41 | $81 | HO2S11 Heater Current (P0053) | Amps |
| $45 | $81 | HO2S21 Heater Current (P0059) | Amps |

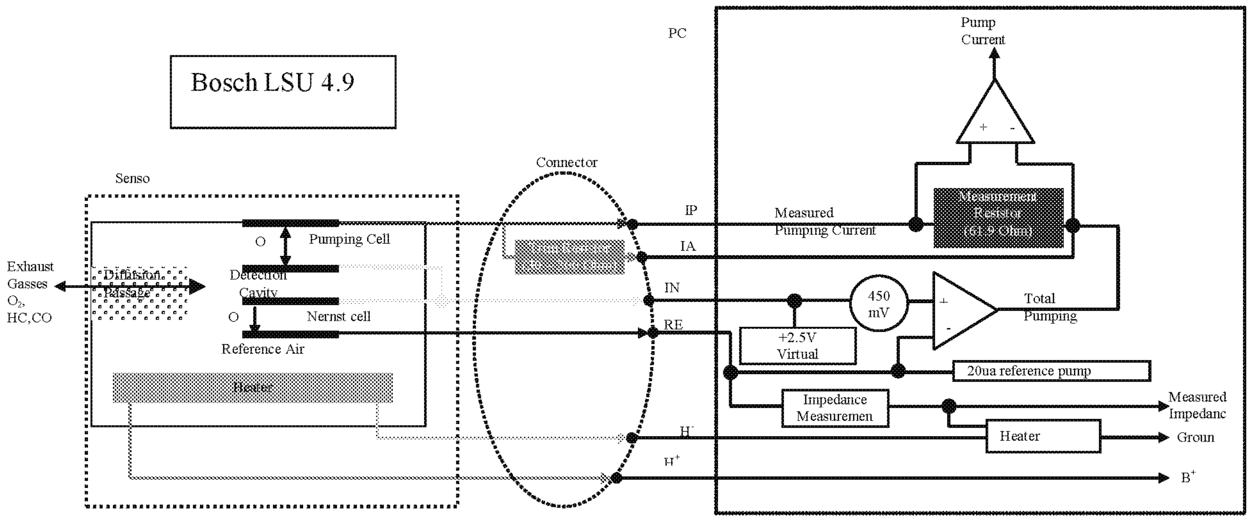
# HO2S Monitor



# Front UEGO Monitor

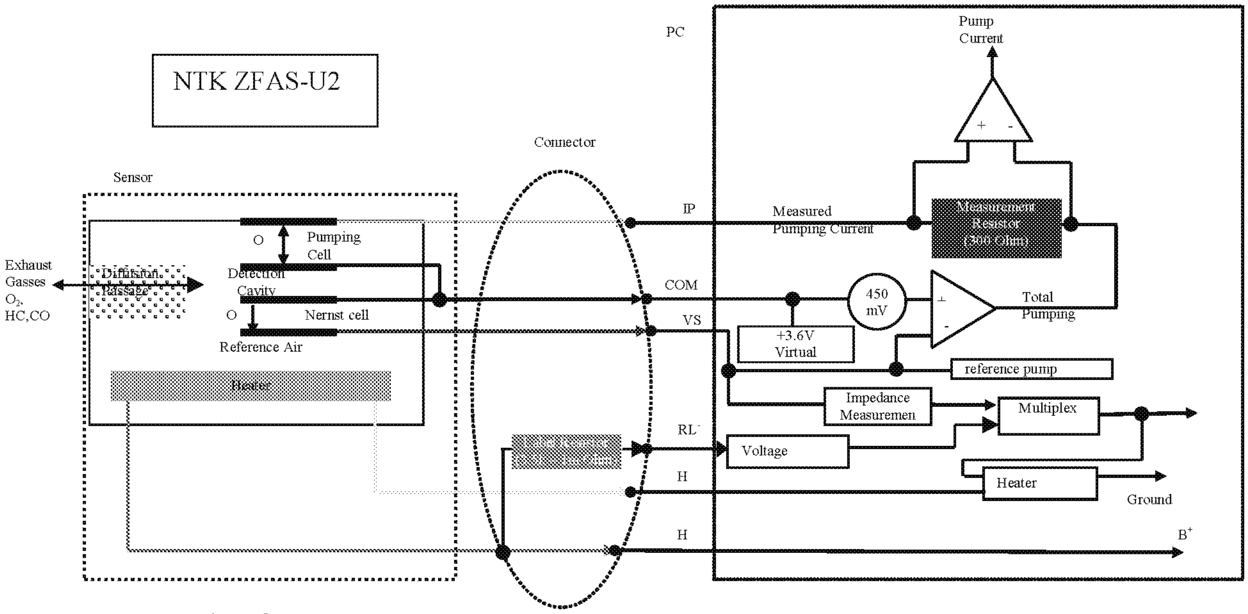
## Front UEGO Signal

The UEGO sensor infers an air fuel ratio relative to the stoichiometric (chemically balanced) air fuel ratio by balancing the amount of oxygen pumped in or out of a measurement chamber. As the exhaust gasses get richer or leaner, the amount of oxygen that must be pumped in or out to maintain a stoichiometric air fuel ratio in the measurement chamber varies in proportion to the air fuel ratio. By measuring the current required to pump the oxygen in or out, the air fuel ratio (lambda) can be estimated. Note that the measured air fuel ratio is actually the output from the UEGO ASIC pumping current controller and not a signal that comes directly from the sensor.




Bosch UEGO sensor interface:

- IP – primary pumping current that flows through the sensing resistor
- IA – current flow through trim resistor in parallel with sense resistor.
- VM – Virtual ground, approximately 2.5 volts above PCM ground.
- RE – Nernst cell voltage, 450mv from VM. Also carries current for pumped reference.
- H+ – Heater voltage – to battery.
- H- – Heater ground side – Duty cycle on/off to control sensor temperature.




NTK UEGO sensor interface:

IP – primary pumping current that flows through the sensing resistor
COM – Virtual ground, approximately 3.6 volts above PCM ground.
VS – Nernst cell voltage, 450mv from COM. Also carries current for pumped reference.
RL - Voltage input from label resistor.
H+ – Heater voltage – to battery.
H- – Heater ground side – Duty cycle on/off to control sensor temperature.

The primary component of a UEGO sensor is the diffusion passage that controls the flow of exhaust gasses into a detection cavity, a Nernst cell (essentially an EGO sensor inside the UEGO sensor) that measures the air fuel ratio in the detection cavity. A control circuitry in the ASIC chip (mounted in the PCM) controls the pumping current (IP) to keep the detection cavity near stoichiometry by holding the Nernst cell at 450 mV. This Nernst cell voltage (RE, VS) is 450mV from the virtual ground (VM, COM), which is approximately 2.5V (Bosch UEGO) or 3.6V (NTK UEGO) above the PCM ground. For the Nernst cell to generate a voltage when the detection cavity is rich, it needs an oxygen differential across the cell. In older UEGO (and HEGO) sensor designs, this was provided by a reference chamber that was connected to outside air through the wire harness that was subject to contamination and "Characteristic Shift Down (CSD)". The new UEGO sensor uses a pumped reference chamber, which is sealed from the outside to eliminate the potential for contamination. The necessary oxygen is supplied by supplying a 20 uA pumping current across the Nernst cell to pump small amounts of oxygen from the detection cavity to the reference chamber. The pumping cell pumps oxygen ions in and out of the detection cavity from and to the exhaust gasses in response to the changes in the Nernst cell voltage. The pumping current flows through the sense resistor and the voltage drop across the sense resistor is measured and amplified. Offset volts are sent out of the ASIC to one of the PCM's A/D inputs. The PCM measures the voltage supplied by the ASIC, determines the pumping current, and converts the pumping current to measured lambda. In general, the circuitry that measures the pumping current is used to estimate the air fuel ratio in the exhaust system.

The UEGO sensor also has a trim (IA) or label resistor (RL). The biggest source of part to part variability in the measured air fuel ratio is difference in the diffusion passage. This source of variation is simply the piece-to-piece differences from the manufacturing process. To compensate for this source of error, each sensor is tested at the factory and a trim or label resistor is installed in the connector. The value of this resistor is chosen to correlate with the measured difference between a particular sensor and a nominal sensor.

For NTK UEGO, the variation in the Ip signal value is corrected for by a compensation coefficient (CC), and then processed by the PCM. The value of CC (Ip rank) is determined by the value of RL. The PCM must command the ASIC to read the value of RL, so CC can be determined. After measuring the value of the label resistor, the PCM software will multiply the measured pumping current (Ip) by a compensation coefficient and determine a corrected pumping current that is used to calculate the measured exhaust air fuel ratio. During each power up, the PCM will briefly turn the UEGO heater power off, measure the output voltage from the voltage divider several times, average it, and estimate the resistance of the label resistor. The PCM will do this estimation multiple times, and if all samples are consistently within one resistor "rank", then the RL compensation coefficient determination is completed and the resistor "rank" compensation coefficient value will be stored in keep alive memory. On the other hand, if the several readings are not consistently within one rank for some amount of time, then the PCM A/D input is considered not reliable/RL erratic, and a trim circuit erratic malfunction (P164A, P164B) will be set. Conversely, if the estimated resistance is too high, then the software in the PCM will indicate RL circuit shorted to ground or open, and a trim circuit low malfunction (P2627, P2630) will be set. If the estimated resistance is too low, then the software will indicate RL circuit shorted to power, and a trim circuit high malfunction (P2628, P2631) will be set. Once a trim circuit malfunction is detected, then the compensation coefficient of the label resistor "rank" stored in KAM will be used.

For Bosch UEGO, the trim resistor is connected in parallel to the pumping current sense resistor and the pumping current flows through both. The trim resistor adjusts the measured pumping current back to the expected nominal value at any given air fuel ratio (correcting for the sensor to sensor variations in the diffusion passage). Small trim resistors are required for sensors that require more pumping current at any particular lambda. Conversely, for sensors with lower diffusion rates than average, less pumping current is required, so a higher than average impedance trim resistor is installed. When IA circuit is open, all of the pumping current flows through the measuring resistor which increases the measured voltage. Since the pumping current is amplified, the UEGO pumping current to lambda transfer function will reflect the error. The slope of the UEGO sensor transfer function changes, which results in the wrong output of the UEGO signal (the slope of the pumping current to lambda relationship can increase or decrease). For "stoichiometric" air/fuel control applications, an open IA circuit is not monitored since the lambda error is minimal in "stoichiometric" mode. A worst case (40 ohm resistor) open IA was tested on a 2008 MY 3.5L Taurus PZEV and showed no impact on tailpipe emissions.

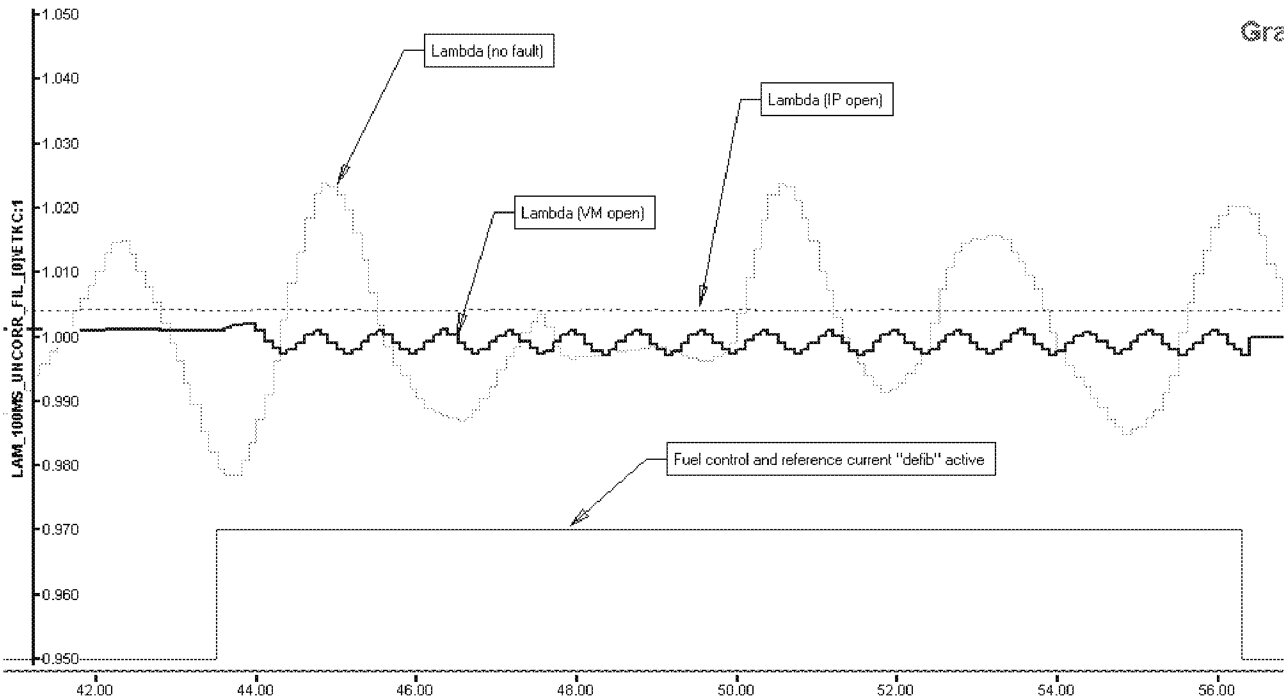
The time spent at the limits of the short term fuel trim is monitored after vehicle startup when closed loop fuel has been requested, during closed loop fuel conditions, or when open loop fuel has been requested due to UEGO sensor fault. Excessive time with short term fuel trim at its limits (up to +/- 40%), or no rich / lean activity seen since startup indicates a "lack of switch" malfunction. Since "lack of switching" malfunctions can be caused by UEGO sensor malfunctions or by shifts in the fuel system, DTCs are stored that provide additional information for the "lack of switching" malfunction. Different DTCs indicate whether the sensor always indicates lean (P2195, P2197), or always indicates rich (P2196, P2198).

| UEGO "Lack of Switching" Operation: | |
|---|---|
| DTCs | P2195 – Lack of switching, sensor indicates lean, Bank 1<br>P2196 – Lack of switching, sensor indicates rich, Bank 1<br>P2197 – Lack of switching, sensor indicates lean, Bank 2<br>P2198 – Lack of switching, sensor indicates rich, Bank 2 |
| Monitor execution | continuous, from startup and while in closed loop fuel or open loop fuel due to UEGO sensor fault |
| Monitor Sequence | None |
| Sensors OK | ECT, IAT, MAF, MAP, VSS, TP, ETC, FRP, FVR, DPFE EGR, VCT, VMV/EVMV, CVS, CPV, EVAPSV, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, no "lack of movement" malfunction, no UEGO circuit malfunction |
| Monitoring Duration | 30 seconds to register a malfunction |

| Typical UEGO "Lack of Switching" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop or Open Loop Requested due to UEGO sensor fault | | |
| No fuel flow entering thru PCV during cold start when flashing off fuel in oil (for O2 Sensor Stuck Rich DTCs only) | | |
| Inferred Ambient Temperature | -40 °F | |
| Time within entry conditions | 10 seconds | |
| Fuel Tank Pressure | | 10 in $H_2O$ |
| Fuel Level | 15% | |
| UEGO ASIC not in recalibration mode | | |
| No air passing through during valve overlap (scavenging). | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO "Lack of Switching" malfunction thresholds: |
|---|
| Stage 1: > 30 seconds since reaching the short term fuel trim limits while closed loop fuel.<br>Stage 2: < 0.5 seconds rich or < 0.5 seconds lean since startup for > 30 seconds in test conditions while open loop fuel is requested due to UEGO sensor fault. |

For Bosch UEGO applications, the time spent when the measured lambda is nearly 1.0 is also monitored after vehicle startup when closed loop fuel has been requested, during closed loop fuel conditions, or when open loop fuel has been requested due to UEGO sensor fault. Excessive time without measured lambda deviating from 1.0, in spite of attempts to force activity (via fuel control and reference current "defib") in the measured lambda, will indicate either a "lack of movement – open Pump Current circuit" malfunction or a "lack of movement - open Reference Ground circuit" malfunction. An open Pump Current circuit (IP) is differentiated from an open Reference Ground circuit (VM) by measuring the movements in the measured lambda during the reference current defib. Change in lambda movement below a minimum threshold indicates "lack of movement- open Pump Current circuit" malfunction, which results in P2237, P2240 DTCs (replaced P0134/P0154 DTCs). Conversely, change in lambda movement greater than the minimum threshold indicates an open VM, which results in P2251, P2254 DTCs (replaced P0130/P0150 DTCs). Note that the open VM detection via reference current defib is new in 2011 MY applications.




Since the Bosch CJ125 or the Conti-Siemens ATIC42 ASIC do not have the capability to specifically detect an open RE or VM, separate diagnostics were created to monitor these failures. An open RE or VM will typically cause the impedance of the Nernst cell to increase. An open RE will cause the UEGO voltage to be greater than or less than a malfunction threshold while an open VM will cause the UEGO voltage to be within a malfunction band. Note that this open VM detection will only enable if the UEGO is unable to control the heater voltage at the desired set point; otherwise, the "lack of movement- open Reference Ground circuit" diagnostic will enable.

| UEGO “Open Circuit Diagnostic – RE, VM ” Operation (Bosch UEGO only): | |
|---|---|
| DTCs | P2243 – O2 Sensor Reference Voltage Circuit/Open (Bank 1, Sensor 1). (replaces P0130)<br>P2247 – O2 Sensor Reference Voltage Circuit/Open (Bank 2, Sensor 1). (replaces P0150)<br>P2251 – O2 Sensor Negative Current Control Circuit/Open (Bank 1, Sensor 1) (replaces P0130)<br>P2254 – O2 Sensor Negative Current Control Circuit/Open (Bank 2, Sensor 1) (replaces P0150) |
| Monitor execution | continuous |
| Monitor Sequence | Intrusive Stream 1 UEGO heater current monitor completed |
| Sensors OK | UEGO heaters OK, no UEGO circuit malfunction |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical UEGO “Open Circuit Diagnostic – RE, VM " entry conditions (Bosch UEGO only): | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| UEGO ASIC not in recalibration mode | | |
| All injectors on (no Decel Fuel Shut Off) | | |
| Short term fuel trim | | 33% |
| Time heater control voltage at maximum limit during open loop heater control | | 9 seconds (Bosch UEGO)<br>20 seconds (NTK UEGO) |
| Time heater control voltage at maximum or minimum limit during closed loop heater control | | 7 seconds (Bosch UEGO)<br>1 second (NTK UEGO) |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO “Open Circuit Diagnostic – RE, VM” malfunction thresholds (Bosch UEGO only): |
|---|
| Open RE circuit: UEGO voltage: > 4.7 V or < 0.2 V for 10 seconds to set a DTC.<br>Open VM circuit: 1.45 V < UEGO voltage < 1.55 V for 10 seconds to set a DTC (Bosch CJ125).<br>1.95 V < UEGO voltage < 2.05 V for 10 seconds to set a DTC (Conti-Siemens ATIC42). |

| UEGO “Lack of Movement – Open Pump Current Circuit” Operation (Bosch UEGO only): | |
|---|---|
| DTCs | P2237 – O2 Sensor Positive Current Control Circuit/Open (Bank 1, Sensor 1) (replaces P0134)<br>P2240 – O2 Sensor Positive Current Control Circuit/Open (Bank 2, Sensor 1) (replaces P0154) |
| Monitor execution | continuous, from startup and while in closed loop fuel or open loop fuel due to UEGO sensor fault |
| Monitor Sequence | None |
| Sensors OK | ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, UEGO heaters OK, no "lack of switching" malfunction, no "lack of movement-open reference ground circuit" malfunction, no UEGO circuit malfunction |
| Monitoring Duration | 10 - 20 seconds to register a malfunction |

| Typical UEGO “Lack of Movement – Open Pump Current Circuit " entry conditions (Bosch UEGO only): | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop or Open Loop Requested due to UEGO sensor fault | | |
| Constant lambda near stoich (~1) | 0.99 | 1.01 |
| Time since no lambda activity seen since start up | 30 sec | |
| Time since no lambda activity during intrusive Stream 1 response monitor | 3 sec | |
| Inferred Ambient Temperature | - 40 °F | |
| Injector fuel pulsewidth | 650 usec | |
| UEGO ASIC not in recalibration mode | | |
| No air passing through during valve overlap (scavenging). | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO “Lack of Movement – Open Pump Current Circuit” malfunction thresholds (Bosch UEGO only): |
|---|
| Stage 1: > 20 seconds in test conditions without lambda movement during fuel control and reference current "defib" while in closed loop fuel and < = 0.05 change in lambda movement.<br>Stage 2: < 0.2 seconds without lambda movement since startup for > 30 seconds in test conditions during reference current "defib" while open loop fuel is requested due to UEGO sensor fault and < = 0.05 change in lambda movement. |

| UEGO “Lack of Movement – Open Reference Ground Circuit ” Operation (Bosch UEGO only): | |
|---|---|
| DTCs | P2251 – O2 Sensor Negative Current Control Circuit/Open (Bank 1, Sensor 1) (replaces P0130)<br>P2254 – O2 Sensor Negative Current Control Circuit/Open (Bank 2, Sensor 1) (replaces P0150) |
| Monitor execution | continuous, from startup and while in closed loop fuel or open loop fuel due to UEGO sensor fault |
| Monitor Sequence | None |
| Sensors OK | ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, UEGO heaters OK, no "lack of switching" malfunction, no "lack of movement-open pump current circuit" malfunction, no UEGO circuit malfunction |
| Monitoring Duration | 10 - 20 seconds to register a malfunction |

| Typical UEGO “Lack of Movement – Open Reference Ground Circuit " entry conditions (Bosch UEGO only): | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop or Open Loop Requested due to UEGO sensor fault | | |
| Constant lambda near stoich (~1) | 0.99 | 1.01 |
| Time since no lambda activity seen since start up | 30 sec | |
| Time since no lambda activity during intrusive Stream 1 response monitor | 3 sec | |
| Injector fuel pulsewidth | 650 usec | |
| UEGO ASIC not in recalibration mode | | |
| No air passing through during valve overlap (scavenging). | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO “Lack of Movement – Open Reference Ground Circuit” malfunction thresholds (Bosch UEGO only): |
|---|
| Stage 1: > 20 seconds in test conditions without lambda movement during fuel control and reference current "defib" while in closed loop fuel and > 0.05 change in lambda movement.<br>Stage 2: > 20 seconds in test conditions without lambda movement during reference current "defib" while open loop fuel is requested due to UEGO sensor fault and > 0.05 change in lambda movement. |

UEGO equipped vehicles monitor the circuitry between the PCM and the UEGO sensor via the wire diagnostics capability included on the UEGO ASIC chip. The wire diagnostics will detect wires (IP, IA, VM/COM, RE/VS) shorted to battery, or ground, and in most cases will detect open circuits (IP, VM/COM, RE/VS). The diagnostic bits are transmitted to the PCM via SPI (serial peripheral interface). The SPI communication is validated continuously, and if a SPI communication failure is detected, fault code(s) P064D and/or P064E will be set. The ASIC is also capable of detecting internal circuitry failure; in which case, an ASIC failure DTC (P1646, P1647) along with the SPI communication failure DTC (P064D, P064E) will be set.

- Beginning 2011 MY, the general UEGO circuit diagnostic DTCs P0130/P0150, are now replaced by more specific DTCs.
- A shorted to ground circuit (Bosch UEGO – IP, IA, RE, VM; NTK UEGO – IP, VS, COM) will set P0131/P0151 DTCs.
- A shorted to battery circuit (Bosch UEGO – IP, IA, RE, VM; NTK UEGO – IP, VS, COM) will set P0132/P0152 DTCs.
- An open Pump Current circuit (IP) will set P2237/P2240 DTCs.
- An open Reference Ground circuit (VM/COM) will set P2251/P2254 DTCs.
- An open Reference Voltage circuit (RE/VS) will set P2243/P2247 DTCs.

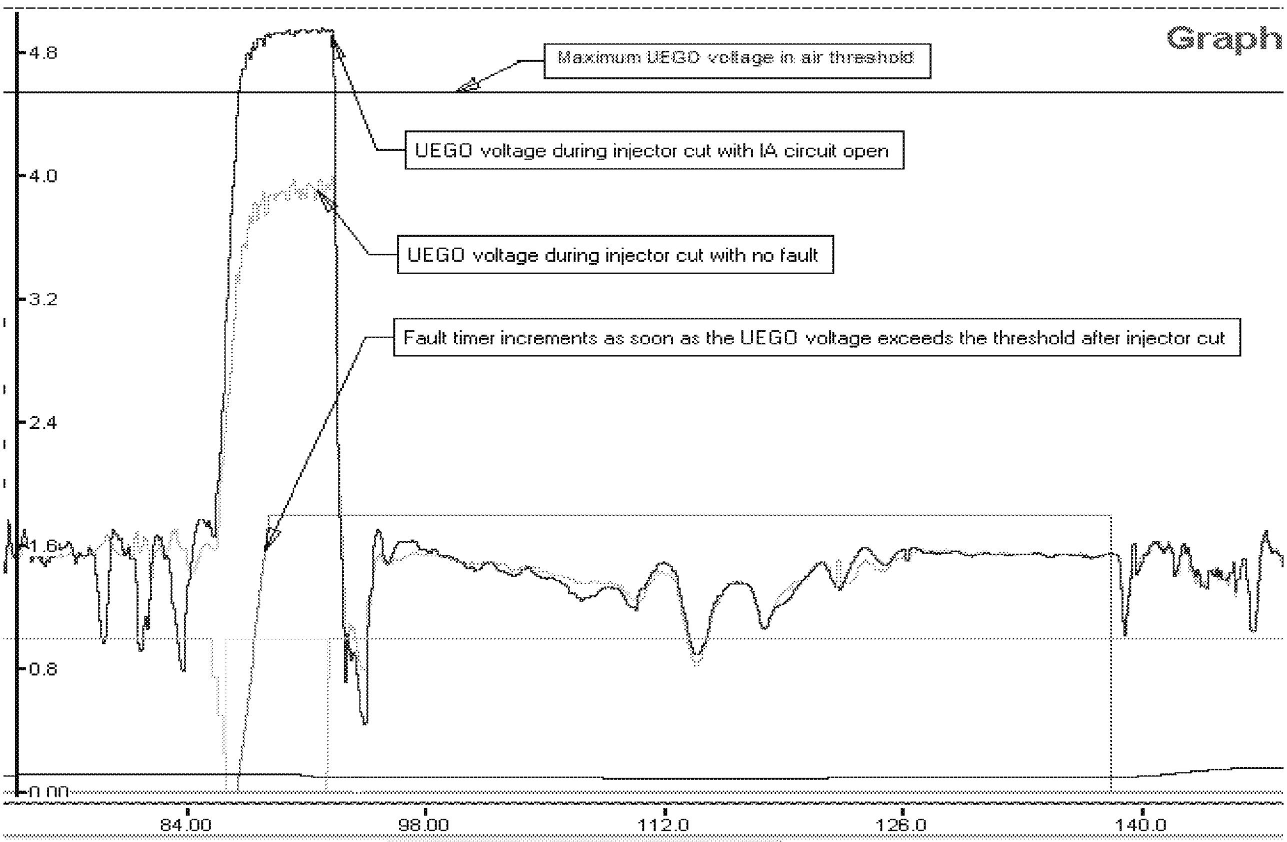
| UEGO "Wire Diagnostic via ASIC" Operation: | |
|---|---|
| DTCs | P0131 – O2 circuit low voltage (Bank 1, Sensor 1). (Note: Sets for short to ground on Bosch UEGO- IP, IA, RE, VM; NTK UEGO – IP, VS, COM. Replaces P0130 in Bosch UEGO applications.)<br>P0151 – O2 circuit low voltage (Bank 2, Sensor 1). (Note: Sets for short to ground on Bosch UEGO- IP, IA, RE, VM; NTK UEGO – IP, VS, COM. Replaces P0150 in Bosch UEGO applications.)<br>P0132 – O2 circuit high voltage (Bank 1, Sensor 1). (Note: Sets for short to battery on Bosch UEGO- IP, IA, RE, VM; NTK UEGO – IP, VS, COM. Replaces P0130 in Bosch UEGO applications.)<br>P0152 – O2 circuit high voltage (Bank 2, Sensor 1). (Note: Sets for short to battery on Bosch UEGO- IP, IA, RE, VM; NTK UEGO – IP, VS, COM. Replaces P0150 in Bosch UEGO applications.<br>P2237 – O2 Sensor Positive Current Control Circuit/Open (Bank 1, Sensor 1). (Note: This DTC sets for open IP. Replaces P0130 in NTK UEGO applications.<br>P2240 – O2 Sensor Positive Current Control Circuit/Open (Bank 2, Sensor 1). (Note: Sets for open IP. Replaces P0150 in NTK UEGO applications).<br>P2243 – O2 Sensor Reference Voltage Circuit/Open (Bank 1, Sensor 1). (Note: Sets for open VS. Replaces P0130 in NTK UEGO applications).<br>P2247 – O2 Sensor Reference Voltage Circuit/Open (Bank 2, Sensor 1). (Note: Sets for open VS. Replaces P0150 in NTK UEGO applications).<br>P2251 – O2 Sensor Negative Current Control Circuit/Open (Bank 1, Sensor 1). (Note: Sets for open COM. Replaces P0130 in NTK UEGO applications).<br>P2254 – O2 Sensor Negative Current Control Circuit/Open (Bank 2, Sensor 1). (Note: Sets for open COM. Replaces P0150 in NTK UEGO applications).<br>P164A – O2 sensor positive current trim circuit performance (Bank 1, Sensor 1). |

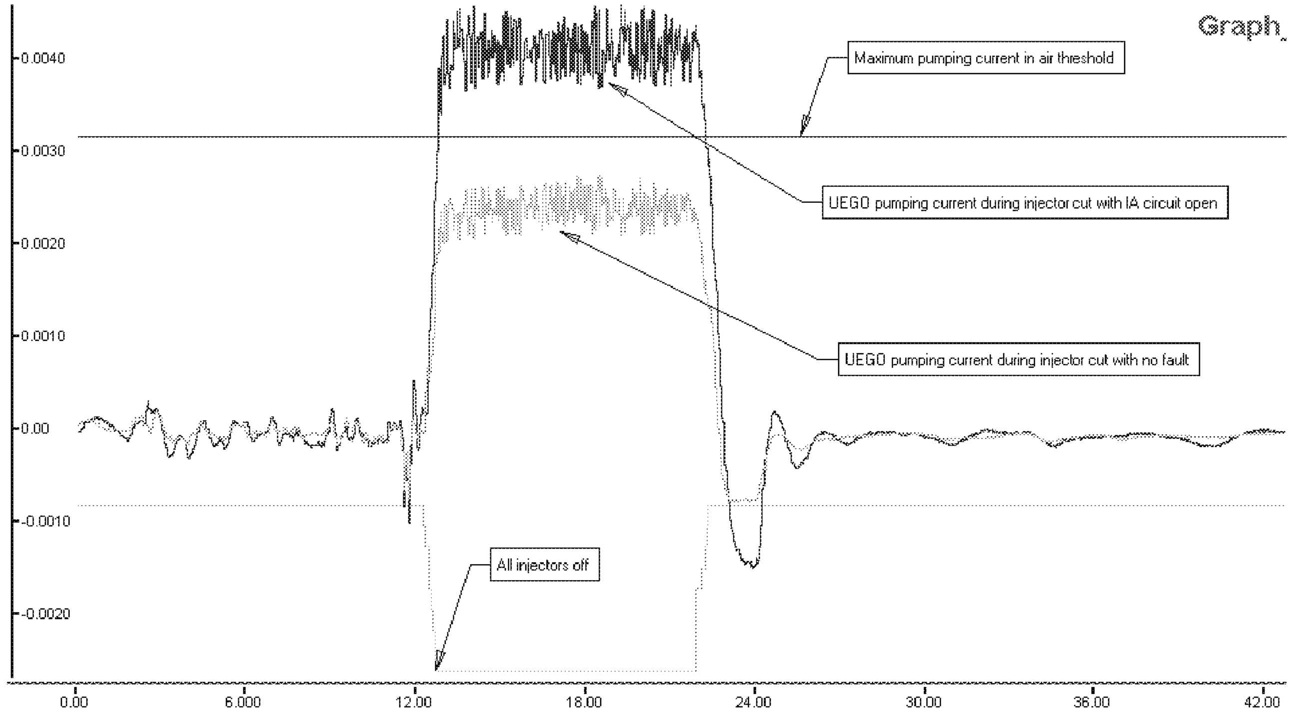
| | |
|---|---|
| | (Note: Sets for an erratic RL in NTK UEGO applications only).<br>P164B – O2 sensor positive current trim circuit performance (Bank 2, Sensor 1). (Note: Sets for an erratic RL in NTK UEGO applications only).<br>P2627 – O2 sensor positive current trim circuit low (Bank 1, Sensor 1). (Note: Sets for open or short to ground RL in NTK UEGO applications only).<br>P2630 – O2 sensor positive current trim circuit low (Bank 2, Sensor 1). (Note: Sets for open or short to ground RL in NTK UEGO applications only).<br>P2628 – O2 sensor positive current trim circuit high (Bank 1, Sensor 1). (Note: Sets for short to battery RL in NTK UEGO applications only).<br>P2631 – O2 sensor positive current trim circuit high (Bank 2, Sensor 1). (Note: Sets for short to battery RL in NTK UEGO applications only).<br>P1646 – Linear O2 sensor control chip, Bank 1.<br>P1647 – Linear O2 sensor control chip, Bank 2.<br>P064D – Internal control module O2 sensor processor performance (Bank 1).<br>P064E – Internal control module O2 sensor processor performance (Bank 2). |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | UEGO heaters OK |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical UEGO "Wire Diagnostic via ASIC" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Fault reported by UEGO ASIC | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO "Wire Diagnostic via ASIC " malfunction thresholds: |
|---|
| UEGO ASIC indicated malfunction, DTC sets after 10 seconds when circuit failure is present. |

For "Non-Stoichiometric Closed Loop (NSCL)" air/fuel control applications, a continuous open IA diagnostics (Air Rationality Test) is required since the lambda error is more significant in this mode. The air rationality test will always monitor the UEGO sensor voltage or pumping current reading during Decel Fuel Shut Off (DFSO) event. The monitor compares the UEGO sensor voltage or pumping current reading in air against the expected value for pure air. If the UEGO sensor voltage or pumping current during DFSO exceeds the maximum UEGO voltage/pumping current in air threshold, then the fault timer increments. If the fault timer exceeds the fault time threshold, then open IA DTC P2626 and/or P2629 will set. Since transient sources of fuel in the exhaust after injector cut can contribute to the UEGO sensor voltage/pumping current to read lower (rich), the air rationality monitor will not call a pass until the transient sources of fuel have been exhausted and pure air entry conditions during DFSO are met (i.e. all injectors must be off, purge must be off, no fuel must be leaking around the PCV valve, and a few transport delays must have passed to allow the last fuel transients to be exhausted leaving nothing for the sensor to see, but air). Note: Beginning 2011 MY and beyond, this diagnostics will monitor the UEGO pumping current against the expected value for pure air instead of the UEGO voltage so the monitor can be ASIC chip independent.






| UEGO "Air Rationality Test" Operation (Bosch UEGO only): | |
|---|---|
| DTCs | P2626 – O2 sensor positive current trim circuit open (Bank 1, Sensor 1)<br>P2629 – O2 sensor positive current trim circuit open (Bank 2, Sensor 1) |
| Monitor execution | continuous, every DFSO event |
| Monitor Sequence | Stream 1 UEGO heater voltage check complete, > 30 seconds time in lack of movement test, > 30 seconds time in lack of switch test |
| Sensors OK | FTP, injectors, UEGO heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no purge system failure, no UEGO circuit malfunction, no UEGO FAOS monitor malfunction, no front UEGO response rate malfunction |
| Monitoring Duration | 2 seconds to register a malfunction |

| Typical UEGO "Air Rationality Test" entry conditions (Bosch UEGO only): | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| No injectors stuck open | | |
| No purge system failure | | |
| Fuel Tank Pressure | | 10 in $H_2O$ |
| Closed pedal | | |
| DFSO entry conditions met | | |
| DFSO requested | | |
| DFSO injectors cut | | |
| No purge flow being requested (pass criteria only) | | |
| No fuel flow entering thru PCV during cold start when flashing off fuel in oil (pass criteria only) | | |
| Transport delay (pass criteria only) | 2 sec | |
| UEGO ASIC not in recalibration mode | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO "Air Rationality Test" malfunction thresholds (Bosch UEGO only): |
|---|
| UEGO voltage: > 4.55 V (max UEGO sensor voltage in air, normal range) or<br>> 3.0 V (max UEGO sensor voltage in air, wide range) for >= 2 seconds in test conditions.<br>UEGO pumping current: > 0.00309 Amps for >= 2 seconds in test conditions. |

## Front UEGO Slow Response Test

The UEGO is also tested functionally. The response rate is evaluated by entering a special 0.5Hz-1.5 Hz. Square wave, fuel control routine. This routine drives the air/fuel ratio around stoichiometry at a calibratable frequency and magnitude, producing predictable oxygen sensor signal amplitude. A slow sensor will show reduced amplitude, measured as a line length. Oxygen sensor signal line length below a minimum threshold indicates a slow sensor malfunction (P0133 Bank 1, P0153 Bank 2). If the calibrated frequency was not obtained while running the test because of excessive purge vapors, etc., the test will be run again until the correct frequency is obtained.

| UEGO "Response Rate" Operation: | |
|---|---|
| DTCs | P0133 (slow response Bank 1), P0153 (slow response Bank 2) |
| Monitor execution | once per driving cycle |
| Monitor Sequence | > 30 seconds time in lack of movement test, > 30 seconds time in lack of switch test |
| Sensors OK | ECT, IAT, MAF, MAP, VSS, TP, ETC, FRP, FVR, DPFE EGR, VCT, VMV/EVMV, CVS, CPV, EVAPSV, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no UEGO circuit malfunction, no UEGO FAOS monitor malfunction |
| Monitoring Duration | 4-12 seconds |

| Typical UEGO "Response Rate" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Flex Fuel Composition not changing | | |
| Not in Phase 0 of Evap Monitor, Purge intrusive test not running | | |
| No Purge System reset | | |
| Not performing CSER spark retard | | |
| Not performing intrusive UEGO Lack of Movement "defib" | | |
| Engine Coolant Temp | 150 °F | 240 °F |
| Intake Air Temp | | 140 °F |
| Time since entering closed loop fuel | 10 seconds | |
| Inferred Catalyst Midbed Temperature | | 1600 °F |
| Fuel Level | 15% | |
| Short Term Fuel Trim Range | -5% | 5% |
| Short Term Fuel Trim Absolute Change while in monitor | | 15% |
| Engine Load | 20% | 70% |
| Maximum change in engine load while in monitor | | 0.25 |
| Vehicle Speed | 35 mph | 80 mph |
| Maximum change in vehicle speed while in monitor | | 3 mph |
| Engine RPM | 1000 rpm | 3000 rpm |
| Maximum change in engine rpm while in monitor | | 150 rpm |
| Commanded versus actual lambda range while in monitor | 0.85 | 1.15 |
| No excessive movement between currently utilized long term fuel trim cells (1 = complete change from one cell to adjacent cell) | | 0.5 |
| UEGO ASIC not in recalibration mode | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO "Response Rate" malfunction thresholds: |
|---|
| Line length (Voltage amplitude): < 15 units |

| J1979 Front UEGO Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| $01 | $84 | UEGO11 voltage length (P0133) | unitless |
| $05 | $84 | UEGO21 voltage length (P0153) | unitless |

## Front UEGO Slow/Delayed Response Monitor (2010 MY+)

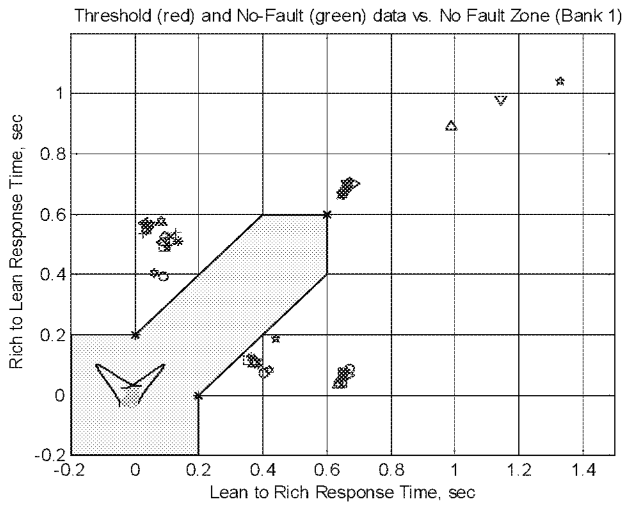
The front UEGO monitor also detects malfunctions on the UEGO sensor such as reduced response or delayed response that would cause vehicle emissions to exceed 1.5x the standard (2.5x the standard for PZEV). The response rate is evaluated by entering a special 0.5 Hz square wave, fuel control routine. This routine drives the air/fuel ratio around stoichiomentry at a calibratable frequency and magnitude, producing predictable oxygen sensor signal amplitude.

A UEGO slow or delayed sensor will show an increased response time which is compared to a no-fault polygon. Combinations of the rich to lean and lean to rich response times that fall outside the polygon indicate a sensor malfunction (P0133 Bank 1, P0153 Bank 2).

| UEGO "Response Rate" Operation: | |
|---|---|
| DTCs | P0133 (slow/delayed response Bank 1), P0153 (slow/delayed response Bank 2) |
| Monitor execution | once per driving cycle |
| Monitor Sequence | > 30 seconds time in lack of movement test, > 30 seconds time in lack of switch test |
| Sensors OK | ECT, IAT, MAF, MAP, VSS, TP, ETC, FRP, FVR, DPFE EGR, VCT, VMV/EVMV, CVS, CPV, EVAPSV, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no UEGO circuit malfunction, no UEGO FAOS monitor malfunction |
| Monitoring Duration | 12 seconds |

| Typical UEGO "Response Rate" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Flex Fuel Composition not changing | | |
| Not in Phase 0 of Evap Monitor, Purge intrusive test not running | | |
| No Purge System reset | | |
| Not performing CSER spark retard | | |
| Not performing intrusive UEGO Lack of Movement "defib" | | |
| No IMRC transition in progress before entering the monitor and while in monitor | | |
| Engine Coolant Temp | 150 $^{o}$F | 240 $^{o}$F |
| Intake Air Temp | | 140 $^{o}$F |
| Time since entering closed loop fuel | 10 seconds | |
| Inferred Catalyst Midbed Temperature | | 1600 $^{o}$F |
| Fuel Level | 15% | |
| Short Term Fuel Trim Range | -5% | 5% |
| Short Term Fuel Trim Absolute Change while in monitor | | 15% |
| Air Mass | 1.2 lbs/min | |
| Engine Load | 20% | 70% |
| Maximum change in engine load while in monitor | | 0.25 |
| Vehicle Speed | 35 mph | 80 mph |
| Maximum change in vehicle speed while in monitor | | 9 mph |
| Engine RPM | 1000 rpm | 3000 rpm |
| Maximum change in engine rpm while in monitor | | 150 rpm |
| Commanded versus actual lambda range while in monitor | 0.85 | 1.15 |
| No excessive cam angle movement over a half cycle A/F modulation when exhaust cam position is >= 40 degree or intake cam position >= -10 degree to indicate an acceptable A/F disturbance due to cam angle movement. | | 3 degree |
| No excessive movement between currently utilized long term fuel trim cells (1 = complete change from one cell to adjacent cell) | | 0.5 |
| UEGO ASIC not in recalibration mode | | |
| No air passing through during valve overlap (scavenging). | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO "Response Rate" malfunction thresholds: |
|---|
| Threshold depends on failure type (symmetric slow/delay vs. Asymmetric slow/delay) |




Example shown with lean-to-rich (0.2 sec), rich-to-lean (0.2 sec), and symmetric (0.6 sec) thresholds creating the yellow no-fault zone. The completeted monitor results in two measurements, a lean-to-rich response time and a rich-to-lean response time. These response time values are used as x-y pairs to make a single point and then compared to the no-fault zone. Anywhere in the yellow is a pass and outside the yellow is a failure.

**J1979 Front UEGO Mode $06 Data**

| Monitor ID | Test ID | Description | |
|---|---|---|---|
| $01 | $87 | UEGO11 Rich to Lean Response Time (P0133) | seconds |
| $01 | $88 | UEGO11 Lean to Rich Response Time (P0133) | seconds |
| $05 | $87 | UEGO21 Rich to Lean Response Time (P0153) | seconds |
| $05 | $88 | UEGO21 Lean to Rich Response Time (P0153) | seconds |

## UEGO Heaters

The UEGO heater is controlled as a function of the measured impedance to keep the sensor at a near constant temperature (Bosch: 780 deg C, NTK: 830 deg C). The impedance of the Nernst cell decreases as the sensor temperature increases. This impedance is measured by periodically applying a small current across the Nernst cell and measuring the change in the voltage. The output voltage is then sent to an A/D input on the PCM. After a cold start, the UEGO heater ramps up to the maximum duty cycle to heat the sensor. After a few seconds, the measured impedance will start to decrease and when the target value is crossed, the heater goes into closed loop heater control to maintain the sensor at a near constant temperature.

The "UEGO Heater Temperature Control Monitor" tracks the time at the maximum duty cycle during the open loop sensor warm up phase. If the measured impedance does not come down to the target value to allow the system to transition from open loop heater control to closed loop heater control within a specified time, then a fault code is set. This monitor also sets a malfunction when the closed loop heater control reaches a maximum or minimum value for a period of time indicating that the controller is no longer able to maintain the target temperature,; however, if the inferred exhaust temperature is high enough that the sensor will be above the target temperature even with no heat, then this monitor is disabled.

The UEGO heaters are also monitored for proper voltage and current. A UEGO heater voltage fault (open, shorted to ground, or shorted to battery) is determined by turning the heater on and off and looking for corresponding voltage change in the heater output driver circuit in the PCM.

A separate current-monitoring circuit monitors heater current once per driving cycle. This monitor normally runs in closed loop heater control after all the exhaust gas sensor functional tests are completed (2010 MY and earlier), however, it can also run intrusively. When the UEGO sensor indicates cold, but the heater is inferred to have been adequately warm, the current monitor is forced to run intrusively prior to the completion of the heater temperature control monitor. The heater current is actually sampled once to three times. Multiple samples are taken for protection against noise on the heater current circuit. If the majority of the current samples fall below or above a calibratable threshold, the heater is assumed to be degraded or malfunctioning.

Beginning 2012MY, some PCMs do not have a separate current-monitoring circuit. For PCMs that do not have the current-monitoring circuit, a degraded or malfunctioning UEGO heater is detected by the "UEGO Heater Temperature Control Monitor".

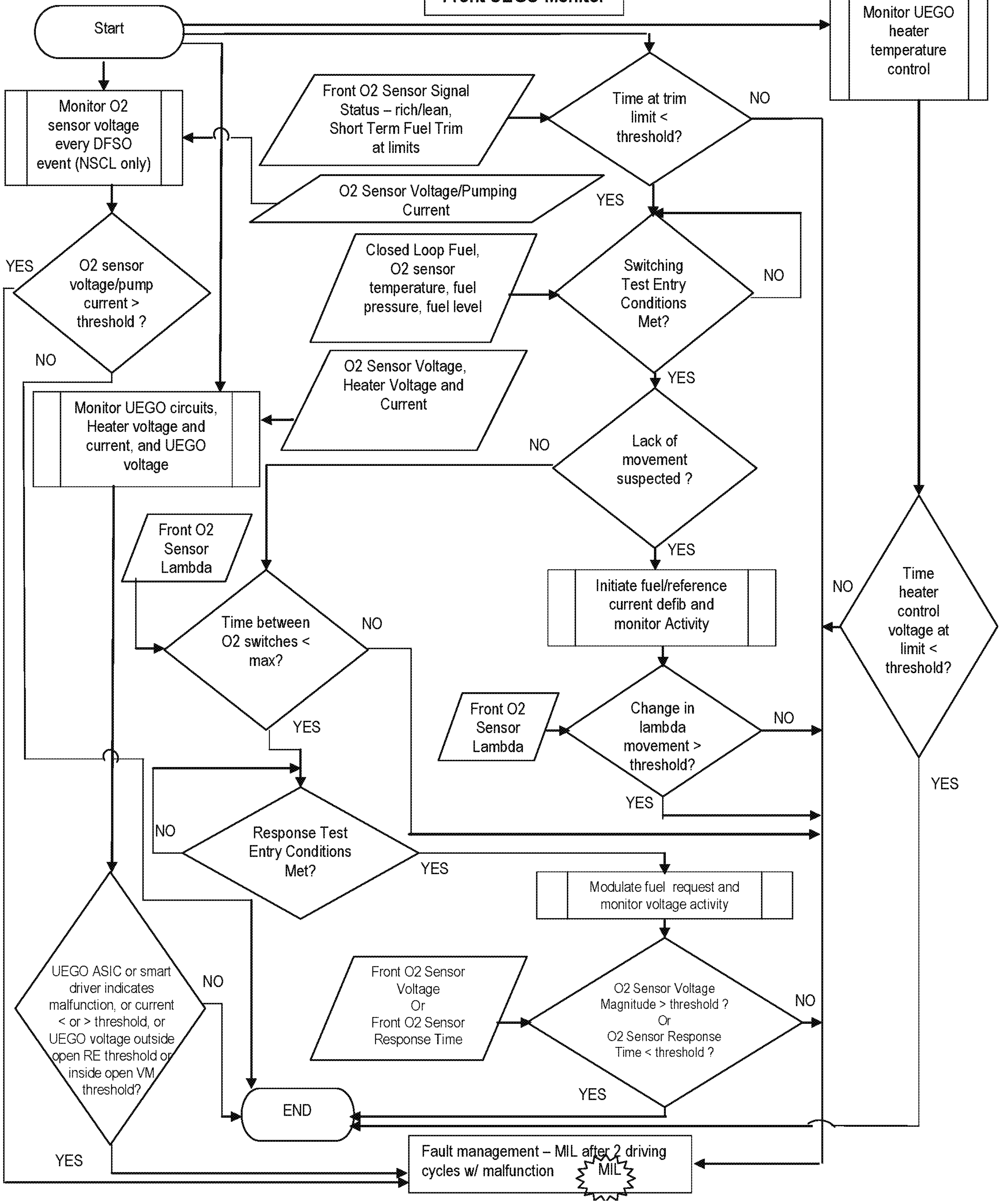
| UEGO Heater Monitor Operation: | |
|---|---|
| DTCs | P0030 Heater Temperature Control Failure, Bank 1<br>P0050 Heater Temperature Control Failure, Bank 2<br>P0135 O2 Heater Circuit, Bank 1<br>P0155 O2 Heater Circuit, Bank 2<br>P0053 O2 Heater Resistance, Bank 1<br>P0059 O2 Heater Resistance, Bank 2 |
| Monitor execution | once per driving cycle for heater current monitor, continuous for voltage monitoring and heater temperature control monitoring |
| Monitor Sequence | Heater current monitor: Stream 1 UEGO response test complete (2010 MY and earlier), Stream 2 and 3 HO2S functional tests complete (2010 MY and earlier), Stream 1 UEGO heater voltage check complete.<br>Heater temperature control monitor: intrusive heater current monitor completed. |
| Sensors OK | Heater current monitor: no HO2S/UEGO heater circuit malfunction, no UEGO heater temperature control malfunction, no UEGO circuit malfunction<br>Heater temperature control monitor: no UEGO circuit malfunction, no UEGO heater circuit malfunction, no UEGO heater current monitor DTCs. |
| Monitoring Duration | < 10 seconds for heater voltage check, < 5 seconds for heater current check, >= 30 seconds for the heater temperature control monitor to register a malfunction |

| Typical UEGO heater monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Inferred UEGO unheated tip temperature (heater voltage check only) | 75 °F | 1562 °F |
| Inferred UEGO heated tip temperature (heater current check only) | 1346 °F | 1526 °F |
| UEGO heater-on time (heater current check only) | 30 seconds | |
| Engine RPM (heater current check only) | | 5000 rpm |
| Time heater control voltage at maximum limit during open loop heater control (intrusive heater current check only | | 9 seconds (Bosch UEGO)<br>20 seconds (NTK UEGO) |
| Time heater control voltage at maximum or minimum limit during closed loop heater control (intrusive heater current check only) | | 7 seconds (Bosch UEGO)<br>1 second (NTK UEGO) |
| Inferred UEGO unheated tip temperature (heater control monitor only) | 75 °F | 1000 °F |
| UEGO ASIC not in recalibration mode | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO heater check malfunction thresholds: |
| --- |
| Smart driver status indicated malfunction (heater voltage check)<br>Number monitor retries allowed for malfunction > = 30 (heater voltage check)<br>Heater current outside limits:<br>< 1.0 Amps or > 3 Amps (intrusive test) or < 0.55 Amps or > 3 Amps (Bosch UEGO)<br>< 1.45 Amps or > 3 Amps (intrusive test) or < 1.05 Amps or > 3 Amps (NTK UEGO)<br>< 1.62 Amps or > 3.80 Amps (intrusive test) or < 1.12 Amps or > 3.80 Amps (Conti-Moto CBP-A2 PCM with NTK UEGO)<br>Heater temperature control monitor: > = 30 seconds to register a malfunction while the heater control integrator is at its maximum or minimum limit |

| J1979 UEGO Heater Mode $06 Data | | | |
| --- | --- | --- | --- |
| Monitor ID | Test ID | Description | Units |
| $41 | $81 | HO2S11 Heater Current (P0053) | Amps |
| $45 | $81 | HO2S21 Heater Current (P0059) | Amps |

## Front UEGO Monitor



# Rear HO2S Monitor

## Rear HO2S Signal

A functional test of the rear HO2S sensors is done during normal vehicle operation. The peak rich and lean voltages are continuously monitored. Voltages that exceed the calibratable rich and lean thresholds indicate a functional sensor. If the voltages have not exceeded the thresholds after a long period of vehicle operation, the air/fuel ratio may be forced rich or lean in an attempt to get the rear sensor to switch. This situation normally occurs only with a green catalyst (< 500 miles). If the sensor does not exceed the rich and lean peak thresholds, a malfunction is indicated.

2005 MY and beyond vehicles will continuously monitor the rear HO2S signal for high voltage, in excess of 1.1 volts and store a unique DTC (P0138, P0158). An over voltage condition is caused by a HO2S heater or battery power short to the HO2S signal line.

2011 MY and beyond vehicles with Conti-Moto CBP-A2 PCM will also continuously monitor the rear HO2S signal for out of range low voltage, below -0.2 volts and store DTC P2A01, P2A04. An out of range low voltage condition is caused by swapped sensor wires (sensor signal and signal return) and sensor degradation.

Furthermore, the rear HO2S signal will also be monitored continuously for circuit open or shorted to ground beginning 2011 MY vehicles with Conti-Moto CBP-A2 PCM or Bosch Tri-core MED 17.x PCM. An intrusive circuit test is invoked whenever the HO2S voltage falls into a voltage fault band. A pull-up resistor is enabled to alter the HO2S circuit characteristics. A very high HO2S internal resistance, > 1 M ohms, will indicate an open HO2S circuit while a low HO2S internal resistance, < 10 ohms, will indicate a HO2S circuit shorted to ground. Both HO2S circuit open and shorted to ground malfunction will set DTC P0137, P0157 if the fault counter exceeds the threshold.

| Rear HO2S Functional Check Operation: | |
|---|---|
| DTCs Sensor 2 | P0136 HO2S12 No activity or<br>P2270 HO2S12 Signal Stuck Lean<br>P2271 HO2S12 Signal Stuck Rich<br>P0156 HO2S22 No activity or<br>P2272 HO2S22 Signal Stuck Lean<br>P2273 HO2S22 Signal Stuck Rich |
| Monitor execution | once per driving cycle for activity test |
| Monitor Sequence | > 30 seconds time in lack of movement test (UEGO only), > 30 seconds time in lack of switch test, front HO2S/UEGO response test complete, Stream 2 HO2S circuit open/short to ground test time slice complete. |
| Sensors OK | ECT, IAT, MAF, MAP, VSS, TP, ETC, FRP, FVR, DPFE EGR, VCT, VMV/EVMV, CVS, CPV, EVAPSV, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO/HO2S (front and rear) heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction (UEGO only), no UEGO/HO2S (front and rear) circuit malfunction, no rear HO2S out of range low malfunction, no UEGO FAOS monitor malfunction, no front HO2S/UEGO response rate malfunction |
| Monitoring Duration | continuous until monitor completed |

| Typical Rear HO2S functional check entry conditions: | | |
| --- | --- | --- |
| Entry condition | Minimum | Maximum |
| Stream 1 HO2S not in CSD recovery mode | | |
| Flex Fuel Composition not changing | | |
| Not in Phase 0 of Evaporative System Monitor | | |
| No Purge System reset | | |
| Purge intrusive test not running | | |
| Not performing CSER spark retard | | |
| Engine Coolant Temp | 150 °F | 240 °F |
| Intake Air Temp | | 140 °F |
| Time since entering closed loop fuel | 10 seconds | |
| Inferred Catalyst Midbed Temperature | | 1600 °F |
| Heater-on Inferred Sensor(s) 2/3 HO2S Temperature Range | 400 °F | 1400 °F |
| Sensor(s) 2/3 HO2S heater-on time | 90 seconds | |
| Short Term Fuel Trim Range | -9% | 11% |
| Fuel Level (forced excursion only) | 15% | |
| Throttle position | Part throttle | |
| Engine RPM (forced excursion only) | 1000 rpm | 2000 rpm |
| UEGO ASIC not in recalibration mode | | |
| No air passing through during valve overlap (scavenging). | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical Rear HO2S functional check malfunction thresholds: |
| --- |
| Does not exceed rich and lean threshold envelope:<br>Rich < 0.42 volts<br>Lean > 0.48 volts |

| J1979 Rear HO2S Functional Check Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| $02 | $01 | HO2S12 sensor switch-point voltage | volts |
| $06 | $01 | HO2S22 sensor switch-point voltage | volts |
| $03 | $01 | HO2S13 sensor switch-point voltage | volts |
| $07 | $01 | HO2S23 sensor switch-point voltage | volts |

| Rear HO2S "Over Voltage Test" Operation: | |
|---|---|
| DTCs | P0138 HO2S12 Over voltage<br>P0158 HO2S22 Over voltage |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | rear HO2S heaters OK |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical HO2S "Over Voltage Test" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Inferred Stream 2/3 HO2S Temperature | 400 $^{o}$F | |
| Sensor(s) 2/3 HO2S heater-on time | 90 seconds | |
| Voltage at sensor 2 HO2S connector | 11.0 Volts | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical HO2S "Over Voltage Test" malfunction thresholds: |
|---|
| > 1.1 volts for 10 seconds for over voltage test |

| Rear HO2S "Out of Range Low Test" Operation: | |
|---|---|
| DTCs | P2A01 HO2S12 Circuit Range/Performance (Bank 1 Sensor 2)<br>P2A04 HO2S22 Circuit Range/Performance (Bank 2 Sensor 2) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | rear HO2S heaters OK, no rear HO2S shorted to ground malfunction |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical HO2S "Out of Range Low Test" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Inferred Stream 2 HO2S Temperature | 400 °F | |
| Sensor 2 HO2S heater-on time | 90 seconds | |
| Voltage at sensor 2 HO2S connector | 11.0 Volts | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical HO2S "Out of Range Low Test" malfunction thresholds: |
|---|
| < -0.2 volts for 10 seconds for out of range low test |

| Rear HO2S "Circuit Open/Shorted to Ground Test" Operation: | |
|---|---|
| DTCs | P0137 HO2S12 Circuit Low Voltage (Bank 1 Sensor 2)<br>P0157 HO2S22 Circuit Low Voltage (Bank 2 Sensor 2) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | rear HO2S heaters OK, no rear HO2S out of range low malfunction, no rear HO2S functional DTCs |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical HO2S "Circuit Open/Shorted to Ground Test" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop | | |
| Inferred Stream 2 HO2S Temperature | 680 °F | 1290 °F (short to ground) |
| Inferred Stream 2 HO2S Element Temperature (applicable only if Stream 2 HO2S Heater Impedance Monitor is enabled) | 480 °F | |
| Time Stream 2 HO2S inferred element temperature within 10% of the predicted steady state temperature (applicable only if Stream 2 HO2S Heater Impedance Monitor is enabled) | 1 second | |
| Sensor 2 HO2S heater-on time | 60 seconds | |
| All injectors on (no Decel Fuel Shut Off) | | |
| Not commanding lean lambda due to torque reduction | | |
| Not requesting enrichment due to catalyst reactivation following decel fuel shut off | | |
| Sensor 2 HO2S voltage (open circuit voltage fault band): | | |
| Conti-Moto CBP-A2 PCM | -0.05 Volts | 0.05 Volts |
| Bosch Tri-Core MED17.x PCM | 0.40 Volts | 0.50 Volts |
| Sensor 2 HO2S voltage (circuit shorted to ground voltage fault band): | | |
| Conti-Moto CBP-A2 PCM | -1.00 Volts | 0.05 Volts |
| Bosch Tri-Core MED17.x PCM | -1.00 Volts | 0.05 Volts |
| Voltage at sensor 2 HO2S connector | 11.0 Volts | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical HO2S "Circuit Open/Shorted to Ground Test" malfunction thresholds: |
|---|
| HO2S Circuit Open: > 1 M ohms, fault counter > 14 (200 msec test every 500 msec check) |
| HO2S Circuit Shorted to ground: < 10 ohms, fault counter > 17 (100 msec test every 500 msec check) |

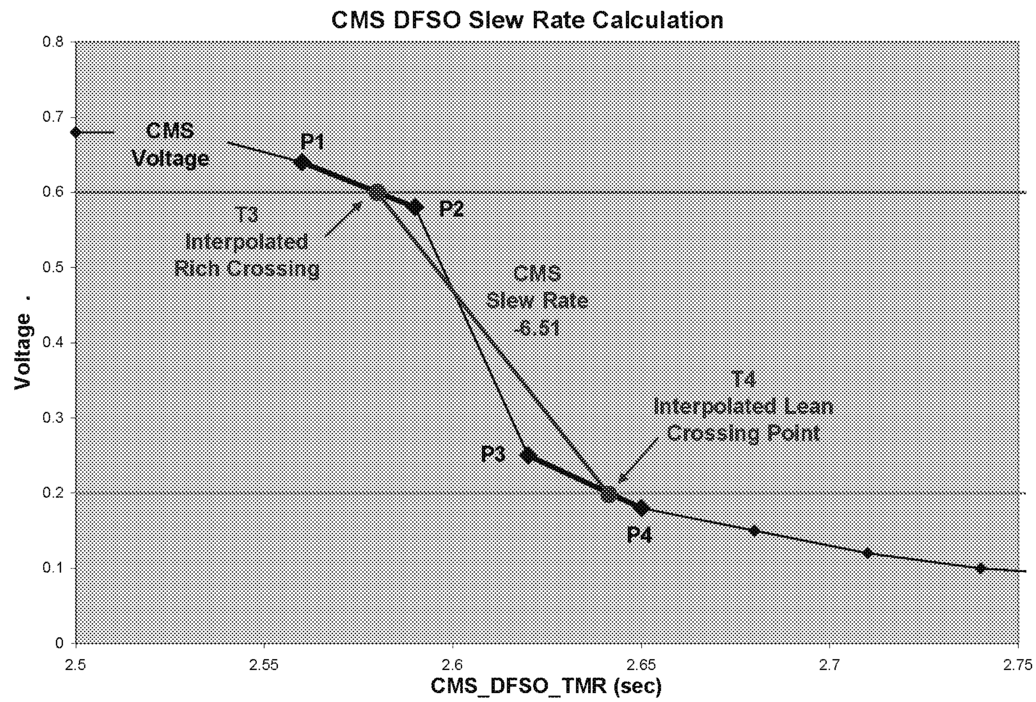
## Rear HO2S Decel Fuel Shut Off Response Test (2009 MY+)

The catalyst monitor tracks and uses the length of the rear HO2S signal. The rear HO2S is also known as the Catalyst Monitor Sensor (CMS). As the catalyst ages, air/fuel fluctuations begin to break through the catalyst and the length of this signal increases. Eventually the length of the CMS signal becomes long enough to identify a failure for the catalyst monitor.

When an HO2S sensor degrades, it's response to air/fuel fluctuations slows down. The effect of a slow rear HO2S sensor on the catalyst monitor is to reduce the length of the signal. A slow CMS sensor, therefore, may cause the catalyst monitor to incorrectly pass a failed catalyst. The purpose of the Rear DFSO Response diagnostic is to ensure the catalyst monitor has a valid CMS sensor with which to perform the catalyst monitor diagnostic. The monitor is set to trigger at the level of degradation that will cause the catalyst monitor to falsely pass a malfunction threshold catalyst.

The OBD-II regulations require this monitor to utilize Decel Fuel Shut Off (DFSO). Ford plans to aggressively use DFSO starting in the 2009 MY on many applications to improve fuel economy. The DFSO rear O2 response test will be phased in coincident with this feature.

The main part of the test is the measured rich to lean response rate. It is determined by a "slew" rate calculation which determines the rich to lean slope of the sensor during a Decel Fuel Shut Off (DFSO) event which occurs during closed pedal at vehicle speeds higher than 28 mph. The calculation for the slew rate (mV/sec) is illustrated below.



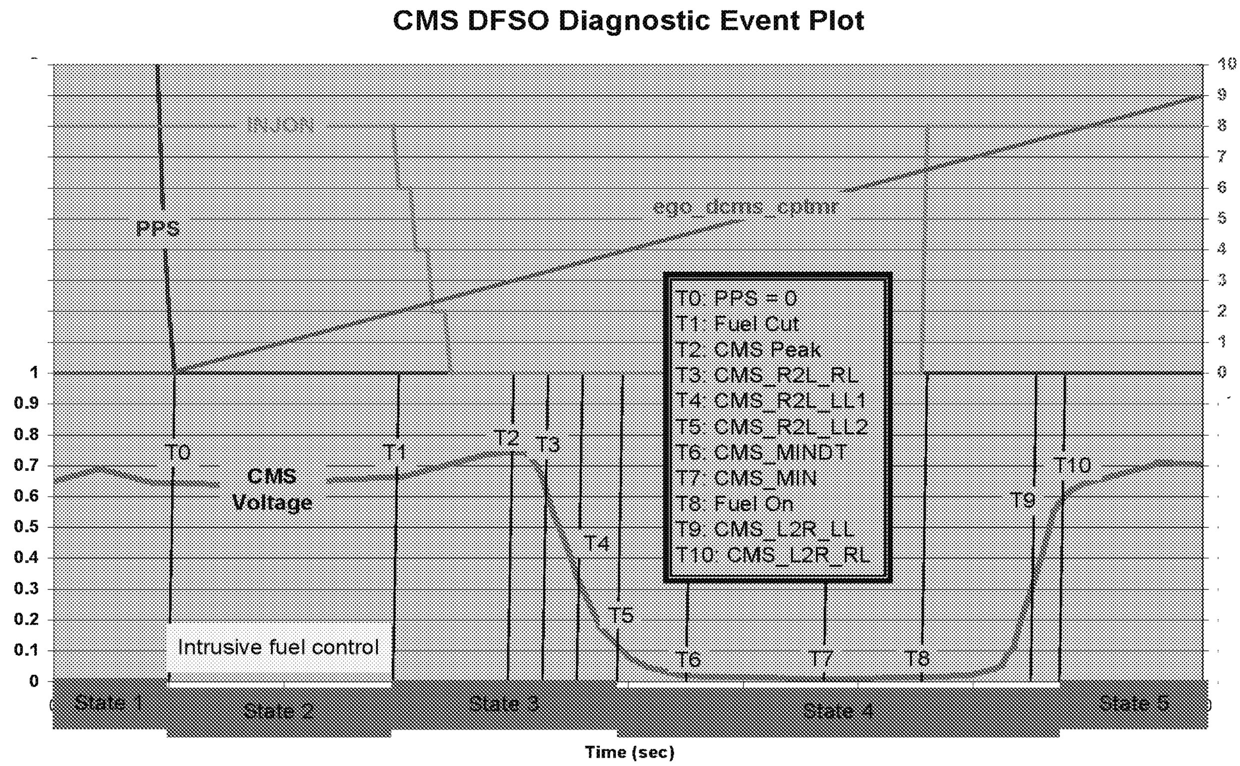

Linear interpolation is performed to calculate the Slew Rate.

1. Interpolate between points P1 and P2 to determine the time at which the rich limit threshold of 0.6 volts was crossed.

2. Interpolate between points P3 and P4 to determine the time at which the lean limit threshold of 0.2 volts was crossed.

3. Use the Interpolated times and the thresholds to calculate the slope or "slew rate" of the CMS sensor from 0.6 to 0.2 volts.

Diagnostic Data Acquisition Event Plot is a schematic of what happens when the pedal is closed and the engine enters DFSO.




The top half of the graph shows the following signals:

Closed pedal timer (ego_dcms_cptmr).

PPS (Pedal Position Sensor)

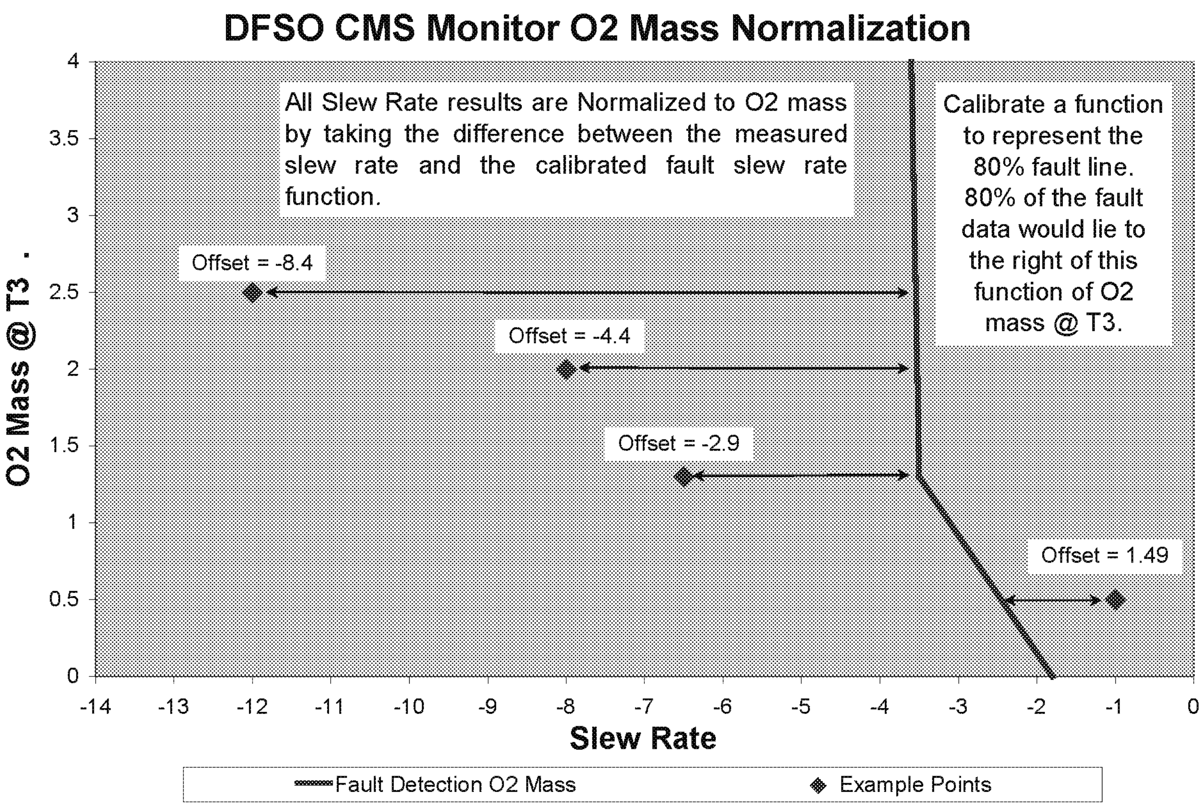
INJON (# of fuel injectors turned on)

The bottom half of the graph shows a CMS signal with black lines and a "Tx" number representing all of the points of interest where the monitor captures data.

The monitor measures the CMS Rich to Lean slew rate during a DFSO event. The CMS voltage must be rich prior to the injector cut for a valid measurement event. Each fuel cut can only yield 1 valid event. The monitor will complete after 3 valid events. Additional valid event results will be stored and applied over the next drive cycle if necessary for monitor completion.

The slope or slew rate of the CMS sensor going from rich to lean is a negative number with the units of mVolts/sec. The measured slew rate changes as an O2 sensor degrades, but it will also change as a function of catalyst oxygen storage/age; therefore, the slew rate is normalized using an offset based on catalyst oxygen storage/age. The catalyst oxygen storage/age is calculated by integrating the level of oxygen mass in the exhaust stream from the time the injectors turn off to the time where the slew rate calculation begins. The fault line (red line in the chart below) is calibrated to 80% of the fault distribution for various levels of oxygen storage/catalyst age. As shown below, the integrated oxygen mass becomes smaller with catalyst age.

The final output of the monitor = the measured slew rate – normalized fault line, therefore, any positive number will represent a fault. For the step change logic the fault threshold will represent 50% of the failed distribution (~ 0.3).



The delayed response part of the test indicates that the sensor is stuck in range. The code sets if the sensor can't get above a calibrated rich or lean voltage prior to a calibrated time out period. This time out must happen three times in a row to set the fault. If it happens once or twice and then the response monitor completes, the counter will be reset and the sensor will have to fail 3 times in a row to again set the DTC.

Due to the fact that intrusively driving the CMS sensor rich will cause drivability and emission concerns, there are other several condition counters that have to fail prior to intrusively forcing the sensor to go rich. The sequence of events to get to the rich failure is shown below:

- Initially, in order to avoid excess emissions, the monitor will only run if the CMS voltage is rich (> 0.6 volts) or CMS sensor is transitioning from lean to rich (large positive slope . 0.2).
  - Successive failures are counted up; when the count exceeds 5 to 10 failures the monitor will now intrusively force rich fuel to run the test.
- In order to avoid a drivability issues as a result of a lean shifted bank, the first phase of intrusive control has a short time out (1 to 2 seconds).
  - Successive failures are counted up; when the count exceeds 3 failures the monitor will now intrusively force rich fuel to failure or a rich sensor.
- All controllable measures have failed to force the sensor to switch, so the strategy will drive rich until the sensor switches or the failure time out is exceeded (5 to 10 seconds).
  - Successive failures are counted up; when the count exceeds 3 failures the monitor will now set a fault (P013E for bank 1 or P014A for bank 2).

If the sensor is stuck rich (can't get lean) the fault procedure is:

- While the injectors remain off, the sensor must get lean (<0.1 volts) prior to the failure time which must be set to account for a green catalyst (5 to 10 seconds).
  - Successive failures are counted up; when the count exceeds 3 failures the monitor will now set a fault (P013E for bank 1 or P014A for bank 2).

**EWMA Fault Filtering**

The EWMA logic incorporates several important CARB requirements. These are:

- Fast Initial Response (FIR): The first 4 tests after a battery disconnect or code clear will process unfiltered data to quickly indicate a fault. The FIR will use a 2-trip MIL. This will help the service technician determine that a fault has been fixed.

- Step-change Logic (SCL): The logic will detect an abrupt change from a no-fault condition to a fault condition. The SCL will be active after the 4$^{th}$ DCMS monitor cycle and will also use a 2-trip MIL. This will illuminate the MIL when a fault is instantaneously induced.

- Normal EWMA (NORM): This is the normal mode of operation and uses an Exponentially Weighted Moving Average (EWMA) to filter the DCMS test data. It is employed after the 4$^{th}$ DCMS test and will illuminate a MIL during the drive cycle where the EWMA value exceeds the fault threshold. (1 trip MIL).

| Rear O2 DFSO Response Monitor Operation: | |
|---|---|
| DTCs | P013A – O2 Sensor Slow Response – Rich to Lean (Bank 1 Sensor 2)<br>P013C – O2 Sensor Slow Response – Rich to Lean (Bank 2 Sensor 2)<br>P013E – O2 Sensor Delayed Response – Rich to Lean (Bank 1 Sensor 2) (sensor stuck in range)<br>P014A – O2 Sensor Delayed Response – Rich to Lean (Bank 2 Sensor 2) (sensor stuck in range) |
| Monitor execution | Once per driving cycle, after 3 DFSO events. |
| Monitor Sequence | > 30 seconds time in lack of movement test (UEGO only), > 30 seconds time in lack of switch test, front HO2S/UEGO response test complete, HO2S 2 and 3 functional tests complete, HO2S/UEGO heater voltage and current checks complete, FAOS monitor system bias maturity met (UEGO applications only) |
| Sensors OK | ECT, IAT, MAF, VSS, TP, ETC, FRP, EGR, VCT, VMV/EVMV, CVS, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, rear HO2S heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no UEGO circuit malfunction, no rear stream 2 HO2S circuit malfunction, no rear stream 2 HO2S functional DTCs, Not performing CSER spark retard. Flex fuel composition not changing. No intrusive EGO monitors running. |
| Monitoring Duration | 3 DFSO events, 450 seconds on the FTP. |

| Typical DFSO Response Monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Air Mass | 0.5 | 6 |
| Vehicle Speed | | 90 |
| Inlet Air Temp | | 140 |
| Engine Coolant Temp | 155 °F | 240 °F |
| Catalyst Temperature (Inferred) | 800 °F | 1600 °F |
| Rear Ego Tip Temperature (Inferred) | 800 °F | |
| Fuel Level | 15% | |
| Fuel In Control | -5% | 5% |
| Adaptive Fuel Within Limits | -5% | 5% |
| Battery Voltage | 11.0 Volts | 18.0 Volts |
| Rich Voltage on downstream CMS sensor(s) | 0.6 Volts | |
| Rich Voltage on upstream HEGO / UEGO sensor(s) | 0.45 Volts (HEGO) | 1 (UEGO) |

| Typical DFSO response rate malfunction thresholds: | |
|---|---|
| Rich to lean slew rate thresholds: | |
| Normal Threshold | = > 0.0 mV/sec |
| Fast Initial Response Threshold | = > 0.0 mV/sec |
| Step Change Threshold | = > 0.3 mV/sec |
| Note that the thresholds use a normalized offset and the threshold is set at "zero". | |

| Typical DFSO delayed response malfunction thresholds: |
|---|
| Successive failures are counted up (5 to 10 faults). Monitor will now intrusively force rich fuel to run the test. |
| Intrusive controls will time out based on drivability (1 to 2 sec). |
| Successive drivability failures are counted up (3 faults). |
| Intrusive controls will now time out at a slower time (5 to 10 sec) and count a fault. After 3 faults are counted, a DTC is set. |

| J1979 DFSO response rate Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| $02 | $85 | HO2S12 Fuel Shut off Rich to Lean Response Rate (P013A) | mV/sec |
| $02 | $86 | HO2S12 Fuel Shut off Rich to Lean Response Time (P013E) | msec |
| $06 | $85 | HO2S22 Fuel Shut off Rich to Lean Response Rate (P013C) | mV/sec |
| $06 | $86 | HO2S22 Fuel Shut off Rich to Lean Response Time (P014A) | msec |

## Rear HO2S Heaters

The HO2S heaters are monitored for proper voltage and current. A HO2S heater voltage fault (open, shorted to ground, or shorted to battery) is determined by turning the heater on and off and looking for corresponding voltage change in the heater output driver circuit in the PCM.

A separate current-monitoring circuit monitors heater current once per driving cycle. The heater current is actually sampled once to three times. Multiple samples are taken for protection against noise on the heater current circuit. If the majority of the current samples fall below or above a calibratable threshold, the heater is assumed to be degraded or malfunctioning.

Beginning 2012MY, some PCMs do not have a separate heater current-monitoring circuit (without shunt resistors that can directly measure the current through the HEGO heaters). In this case, the sensor heater performance is monitored by the "HO2S Heater Impedance Monitor". The HO2S heater impedance monitor measures the HO2S internal impedance, validates the measurement, and then compares the validated internal impedance to an internal impedance threshold. If the validated internal impedance exceeds the threshold, then the monitor fault counter increments once. If the fault counter exceeds the total number of valid internal impedance measurements required, a HO2S heater control circuit range/performance malfunction (P00D2/P00D4) will be set.

Any corrosion in the harness wiring, connector, or increase in the sensor heater element resistance will result in an overall increase in the heater circuit resistance, causing the HO2S impedance to increase. The impedance is dependent on the HO2S element temperature and the voltage at the connector. As the HO2S element temperature increases, the impedance decreases. Furthermore, as the voltage at the connector increases, the sensor impedance decreases. Hence, the impedance threshold is a function of the inferred HO2S element temperature and the voltage at the connector.

The HO2S heater impedance monitor runs once per trip; however, it can be forced to run intrusively. When the heater is inferred to have been adequately warm, but the HO2S sensor is suspected to be cold because the HO2S voltage falls inside the suspected open HO2S circuit voltage fault band or inside the suspected HO2S circuit shorted to ground voltage fault band, a HEGO sensor circuit or HEGO heater malfunction is suspected. To differentiate HO2S signal circuit failures from a degraded/malfunctioning heater or normal FAOS control, the HO2S heater impedance monitor is forced to run intrusively after the heater voltage test and the HO2S open/short to ground circuit diagnostics had ran and indicated no malfunction.

| HO2S Heater Monitor Operation: | |
|---|---|
| DTCs Sensor 2 | P0141 O2 Heater Circuit, Bank 1<br>P0161 O2 Heater Circuit, Bank 2<br>P0054 O2 Heater Resistance, Bank 1<br>P0060 O2 Heater Resistance, Bank 2<br>P00D2 HO2S Heater Control Circuit Range/Performance (Bank 1, Sensor 2)<br>P00D4 HO2S Heater Control Circuit Range/Performance (Bank 2, Sensor 2) |
| DTCs Sensor 3 | P0147 O2 Heater Circuit, Bank 1<br>P0167 O2 Heater Circuit, Bank 2<br>P0055 HO2S Heater Resistance, Bank 1<br>P0061 HO2S Heater Resistance, Bank 2 |
| Monitor execution | once per driving cycle for heater current monitor and HO2S heater impedance monitor, continuous for voltage monitoring |
| Monitor Sequence | Heater current monitor: Stream 1 HO2S/UEGO response test complete (2010 MY and earlier), Stream 2 and 3 HO2S functional tests complete (2010 MY and earlier), HO2S/UEGO heater voltage check complete.<br>HO2S heater impedance monitor: Stream 2 HO2S heater voltage check complete, Stream 2 HO2S circuit open/short to ground test time slice complete. |
| Sensors OK | Heater current monitor: no HO2S/UEGO heater voltage DTCs.<br>HO2S heater impedance monitor: rear HO2S heaters OK, no rear HO2S out of range low malfunction, no rear HO2S functional DTCs, no rear HO2S circuit malfunction. |
| Monitoring Duration | < 10 seconds for heater voltage check, < 5 seconds for heater current check, < 11 seconds for HO2S heater impedance test. |

| Typical HO2S heater monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| **Heater Voltage Test:** | | |
| Inferred HO2S 2/3 Temperature | 400 °F | 1400 °F |
| Battery Voltage | 11.0 | 18.0 Volts |
| **Heater Current Test:** | | |
| Inferred HO2S 2 Temperature | 250 °F | 1400 °F |
| Inferred HO2S 3 Temperature | 250 °F | 1400 °F |
| HO2S 1/2/3 heater-on time | 30 seconds | |
| Engine RPM | | 5000 rpm |
| Battery Voltage | 11.0 | 18.0 Volts |
| **HO2S Heater Impedance Test:** | | |
| Inferred Stream 2 HO2S Temperature | 680 °F | |
| Inferred Stream 2 HO2S Element Temperature | 480 °F | 1020 °F |
| Time Stream 2 HO2S inferred element temperature within 10% of the predicted steady state temperature | 1 second | |
| Sensor 2 HO2S heater-on time | 60 seconds | |
| All injectors on (no Decel Fuel Shut Off) | | |
| Not commanding lean lambda due to torque reduction | | |
| Not requesting enrichment due to catalyst reactivation following decel fuel shut off | | |
| Sensor 2 HO2S voltage (open circuit voltage fault band- intrusive test only):<br>Conti-Moto CBP-A2 PCM<br>Bosch Tri-Core MED17.x PCM | -0.05 Volts<br>0.40 Volts | 0.05 Volts<br>0.50 Volts |
| Sensor 2 HO2S voltage (circuit shorted to ground voltage fault band- intrusive test only):<br>Conti-Moto CBP-A2 PCM<br>Bosch Tri-Core MED17.x PCM | -1.00 Volts<br>-1.00 Volts | 0.05 Volts<br>0.05 Volts |
| Voltage at sensor 2 HO2S connector | 11.0 Volts | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

## Typical HO2S heater check malfunction thresholds:

**Heater Voltage Test:**

Smart driver status indicated malfunction

Number monitor retries allowed for malfunction > = 30

**Heater Current Test:**

Heater current outside limits: < 0.220 Amps or > 3 Amps, (NTK)

< 0.400 Amps or > 3 Amps, (Bosch)

< 0.465 Amps or > 3 Amps, (NTK Fast Light Off)

< 0.230 Amps or > 3 Amps, (Bosch Fast Light Off)

**HO2S Heater Impedance Test:**

HO2S internal impedance > table below (ohms), fault counter > = 10

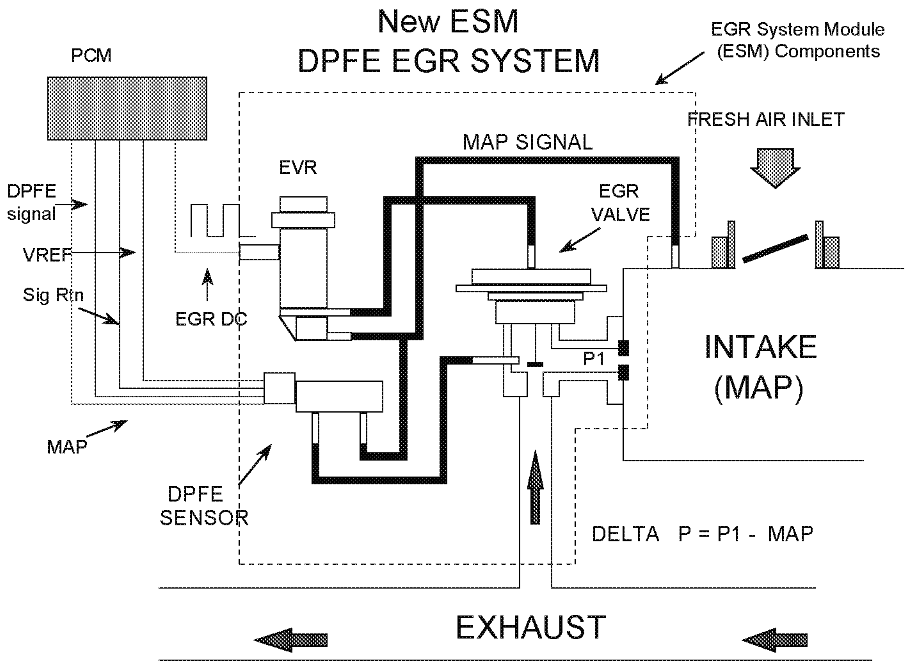
| Voltage at HO2S (Volts)/ HO2S inferred element temp ($^{o}$F) | 11 | 13 | 14 | 15 | 18 |
|---|---|---|---|---|---|
| 480 | 71734 | 26000 | 14583 | 9268 | 2856 |
| 570 | 25864 | 10522 | 6496 | 3733 | 1644 |
| 671 | 8629 | 4057 | 2905 | 2083 | 1175 |
| 730 | 3253 | 1862 | 1399 | 1066 | 576 |
| 770 | 2906 | 1614 | 1223 | 941 | 530 |
| 905 | 838 | 575 | 470 | 383 | 273 |
| 1020 | 675 | 473 | 410 | 359 | 251 |

## J1979 HO2S Heater Mode $06 Data

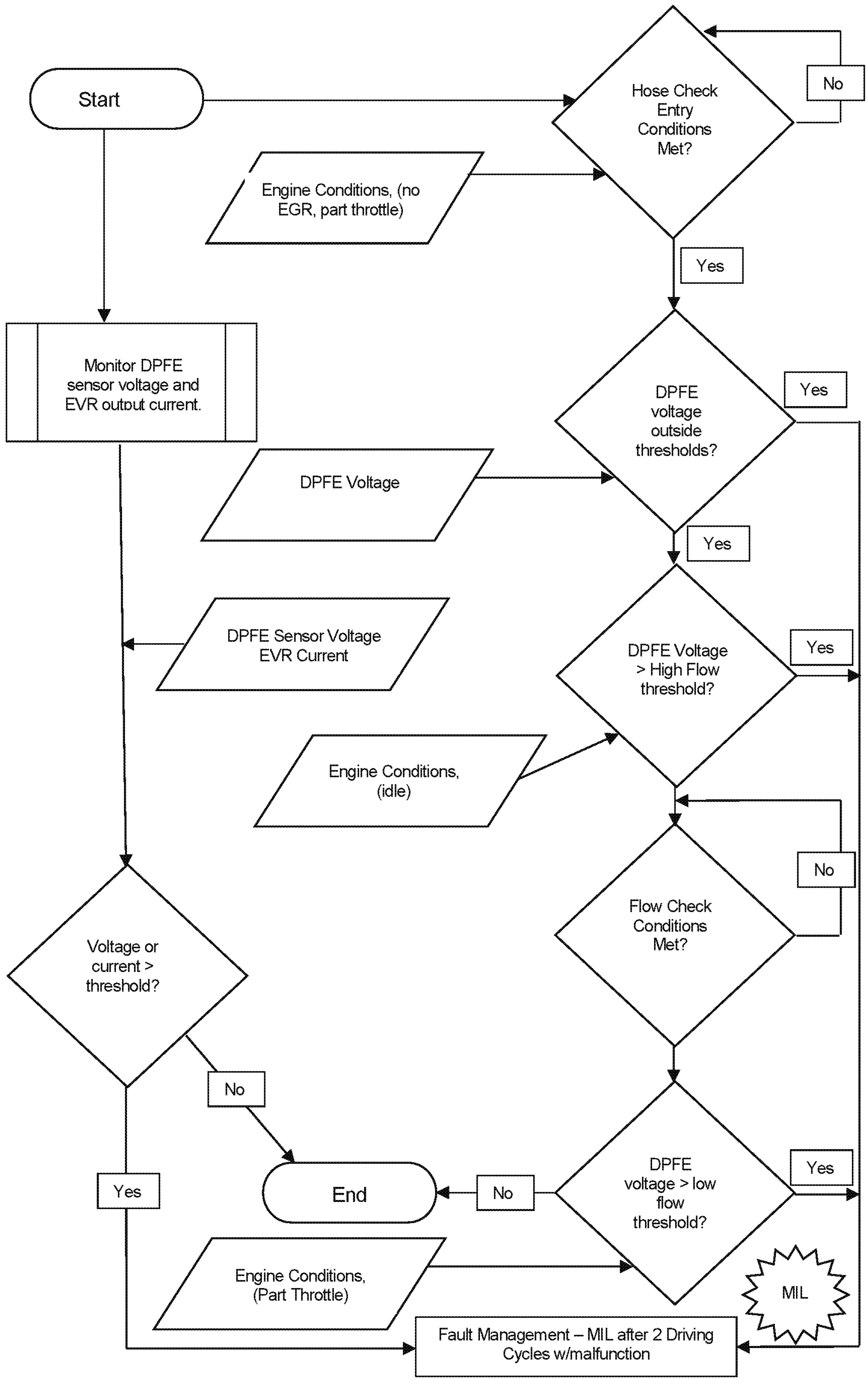
| Monitor ID | Test ID | Description | Units |
|---|---|---|---|
| $42 | $81 | HO2S12 Heater Current (P0054) | Amps |
| $46 | $81 | HO2S22 Heater Current (P0060) | Amps |
| $43 | $81 | HO2S13 Heater Current (P0055) | Amps |
| $47 | $81 | HO2S23 Heater Current (P0061) | Amps |
| $42 | $82 | O2S12 Heater Impedance (P00D2) | kOhm |
| $46 | $82 | O2S22 Heater Impedance ({00D4} | kOhm |

## ESM DPFE EGR System Monitor

In the 2002.5 MY, Ford introduced a revised DPFE system. It functions in the same manner as the conventional DPFE system; however, the various system components have been combined into a single component called the EGR System Module (ESM). This arrangement increases system reliability while reducing cost. By relocating the EGR orifice from the exhaust to the intake, the downstream pressure signal measures Manifold Absolute Pressure (MAP). The ESM will provide the PCM with a differential DPFE signal, identical to the conventional DPFE system. The DPFE signal is obtained by electrically subtracting the MAP and P1 pressure signals and providing this signal to the DPFE input on the PCM. 2003 MY and later implementations of the ESM system has a separate input to the PCM for the MAP sensor signal.



ESM DPFE EGR Monitor



The ESM Delta Pressure Feedback EGR Monitor is a series of electrical tests and functional tests that monitor various aspects of EGR system operation.

First, the Delta Pressure Feedback EGR (DPFE) sensor input circuit is checked for out of range values (P1400 or P0405, P1401 or P0406). The Electronic Vacuum Regulator (EVR) output circuit is checked for opens and shorts (P1409 or P0403).

| EGR Electrical Check Operation: | |
|---|---|
| DTCs | P1400 or P0405 - DPFE Circuit Low<br>P1401 or P0406 - DPFE Circuit High<br>P1409 or P0403 - EVR circuit open or shorted |
| Monitor execution | Continuous, during EGR monitor |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 4 seconds to register a malfunction |

| Typical EGR electrical check entry conditions: |
|---|
| EGR system enabled |

| Typical EGR electrical check malfunction thresholds: |
|---|
| DPFE sensor outside voltage: > 4.96 volts, < 0.0489 volts<br>EVR solenoid smart driver status indicates open/short |

| DPFE Sensor Transfer Function | | |
|---|---|---|
| ESM DPFE volts = Vref [( 0.683 * Delta Pressure) + 10 ] / 100 | | |
| Volts | A/D Counts in PCM | Delta Pressure, Inches $H_2O$ |
| 0.0489 | 10 | -13.2 |
| 0.26 | 53 | -7.0 |
| 0.5 | 102 | 0 |
| 0.74 | 151 | 7.0 |
| 1.52 | 310 | 30 |
| 2.55 | 521 | 60 |
| 3.57 | 730 | 90 |
| 4.96 | 1015 | 130.7 |

Note: EGR normally has large amounts of water vapor that are the result of the engine combustion process. During cold ambient temperatures, under some circumstances, water vapor can freeze in the DPFE sensor, hoses, as well as other components in the EGR system. In order to prevent MIL illumination for temporary freezing, the following logic is used:

If an EGR system malfunction is detected above 32 $^oF$, the EGR system and the EGR monitor is disabled for the current driving cycle. A DTC is stored and the MIL is illuminated if the malfunction has been detected on two consecutive driving cycles.

If an EGR system malfunction is detected below 32 $^oF$, only the EGR system is disabled for the current driving cycle. A DTC is not stored and the I/M readiness status for the EGR monitor will not change. The EGR monitor, however, will continue to operate. If the EGR monitor determined that the malfunction is no longer present (i.e., the ice melts), the EGR system will be enabled and normal system operation will be restored.

The ESM may provide the PCM with a separate, analog Manifold Absolute Pressure Sensor (MAP) signal. For the 2006 MY, the MAP signal has limited use within the PCM. It may be used to read BARO (key on, then updated at high load conditions while driving) or to modify requested EGR rates. Note that if the MAP pressure-sensing element fails in the ESM fails, the DPFE signal is also affected. Therefore, this MAP test is only checking the circuit from the MAP sensing element to the PCM.

The MAP sensor is checked for opens, shorts, or out-of-range values by monitoring the analog-to-digital (A/D) input voltage.

| MAP Sensor Check Operation | |
|---|---|
| DTCs | P0107 (low voltage), P0108 (high voltage) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| MAP electrical check entry conditions: |
|---|
| Battery voltage > 11.0 volts |

| Typical MAP sensor check malfunction thresholds: |
|---|
| Voltage < 0.024 volts or voltage > 4.96 volts |

On ESM DPFE systems, after the vehicle is started, the differential pressure indicated by the ESM DPFE sensor at idle, at zero EGR flow is checked to ensure that both hoses to the ESM DPFE sensor are connected. At idle, the differential pressure should be zero (both hoses see intake manifold pressure). If the differential pressure indicated by the ESM DPFE sensor exceeds a maximum threshold or falls below a minimum threshold, an upstream or downstream hose malfunction is indicated (P1405, P1406).

| **ESM DPFE EGR Hose Check Operation:** | |
|---|---|
| DTCs | P1405 - Upstream Hose Off or Plugged<br>P1406 – Downstream Hose Off or Plugged |
| Monitor execution | once per driving cycle |
| Monitor Sequence | after electrical checks completed |
| Sensors OK | MAF |
| Monitoring Duration | 10 seconds to register a malfunction |

| **Typical ESM DPFE EGR hose check entry conditions:** | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| EVR Duty Cycle (EGR commanded off) | 0% | 0% |
| Closed throttle (warm engine idle) | | |
| Engine Coolant Temperature | 150 °F | 220 °F |

| **Typical ESM EGR hose check malfunction thresholds:** |
|---|
| DPFE sensor voltage: < -0.122 volts (-11.06 in $H_2O$), > 4.69 volts (122.82 in $H_2O$) |

| **J1979 Mode $06 Data** | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for ESM DPFE | |
| $32 | $82 | Delta pressure for upstream hose test and threshold (P1405) | kPa |
| $32 | $83 | Delta pressure for downstream hose test and threshold (P1406) | kPa |

Note: OBD monitor ID $32, Test ID $82 (upstream hose test) may erroneously show a failing test result when no P1405 DTC is present. This is cause by in incorrect max limit in the software. The incorrect max limit will show a negative value (approx -32 kPa). The correct max limit will show a positive value (approx. +32 kPa). Early production vehicles may exhibit this issue until the software is corrected by a production running change or service fix.

Next, the differential pressure indicated by the DPFE sensor is also checked at idle with zero requested EGR flow to perform the high flow check. If the differential pressure exceeds a calibratable limit, it indicates a stuck open EGR valve or debris temporarily lodged under the EGR valve seat (P0402).

| EGR Stuck open Check Operation: | |
|---|---|
| DTCs | P0402 |
| Monitor execution | once per driving cycle |
| Monitor Sequence | done after hose tests completed |
| Sensors OK | CPS, ECT, IAT, MAF, TP, MAP (P0106/7/8) |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical EGR stuck open check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| EVR Duty Cycle (EGR commanded off) | 0% | 0% |
| Engine RPM (after EGR enabled) | at idle | Idle |

| Typical EGR stuck open check malfunction thresholds: |
|---|
| DPFE sensor voltage at idle versus engine-off signal: > 0.6 volts |

| J1979 Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for ESM DPFE | Units |
| $32 | $84 | Delta pressure for stuck open test and threshold (P0402) | kPa |

After the vehicle has warmed up and normal EGR rates are being commanded by the PCM, the low flow check is performed. Since the EGR system is a closed loop system, the EGR system will deliver the requested EGR flow as long as it has the capacity to do so. If the EVR duty cycle is very high (greater than 80% duty cycle), the differential pressure indicated by the DPFE sensor is evaluated to determine the amount of EGR system restriction. If the differential pressure is below a calibratable threshold, a low flow malfunction is indicated (P0401).

| EGR Flow Check Operation: | |
|---|---|
| DTCs | P0401 – Insufficient Flow |
| Monitor execution | once per driving cycle |
| Monitor Sequence | done after P0402 completed |
| Sensors OK | CPS, ECT, IAT, MAF, TP, MAP (P0106/7/8) |
| Monitoring Duration | 70 seconds to register a malfunction |

| Typical EGR flow check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| EVR Duty Cycle | 80% | 100% |
| Engine RPM | | 2500 rpm |
| Mass Air Flow Rate of Change | | 6% program loop |
| Inferred manifold vacuum | 6 in Hg | 10 in Hg |

| Typical EGR flow check malfunction thresholds: |
|---|
| DPFE sensor voltage: < 6 in $H_2O$ |

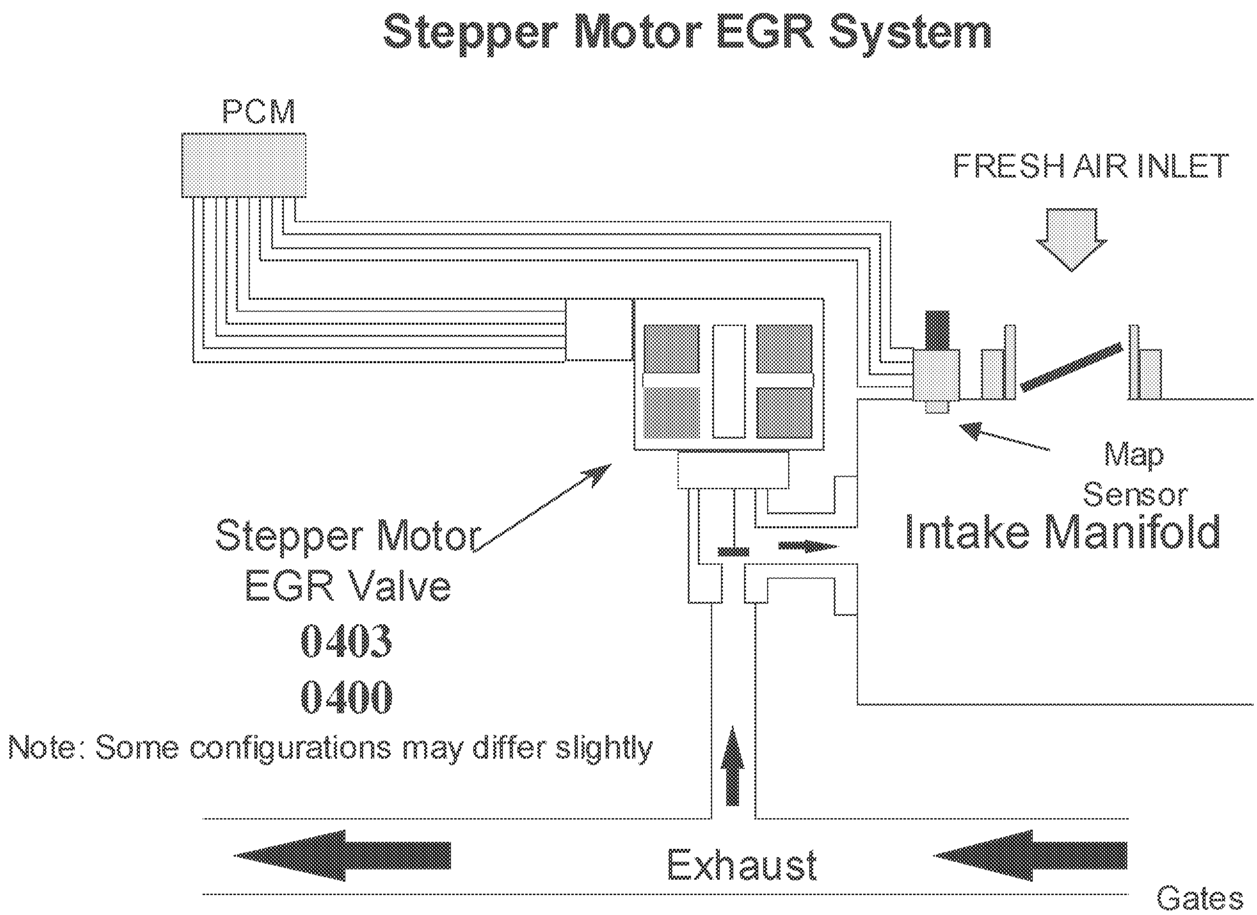
| J1979 Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for ESM DPFE | Units |
| $32 | $85 | Delta pressure for flow test and threshold (P0401) | kPa |

## I/M Readiness Indication

If the inferred ambient temperature is less than 32 $^{o}$F, or greater than 140 $^{o}$F, or the altitude is greater than 8,000 feet (BARO < 22.5 "Hg), the EGR monitor cannot be run reliably. In these conditions, a timer starts to accumulate the time in these conditions. If the vehicle leaves these extreme conditions, the timer starts decrementing, and, if conditions permit, will attempt to complete the EGR flow monitor. If the timer reaches 500 seconds, the EGR monitor is disabled for the remainder of the current driving cycle and the EGR Monitor I/M Readiness bit will be set to a “ready” condition after one such driving cycle. Starting in the 2002 MY, vehicles will require two such driving cycles for the EGR Monitor I/M Readiness bit to be set to a "ready" condition.

## Stepper Motor EGR System Monitor

The Electric Stepper Motor EGR System uses an electric stepper motor to directly actuate an EGR valve rather than using engine vacuum and a diaphragm on the EGR valve. The EGR valve is controlled by commanding from 0 to 52 discreet increments or “steps” to get the EGR valve from a fully closed to fully open position. The position of the EGR valve determines the EGR flow. Control of the EGR valve is achieved by a non-feedback, open loop control strategy. Because there is no EGR valve position feedback, monitoring for proper EGR flow requires the addition of a MAP sensor.



The Stepper Motor EGR Monitor consists of an electrical and functional test that checks the stepper motor and the EGR system for proper flow.

The stepper motor electrical test is a continuous check of the four electric stepper motor coils and circuits to the PCM. A malfunction is indicated if an open circuit, short to power, or short to ground has occurred in one or more of the stepper motor coils for a calibrated period of time. If a malfunction has been detected, the EGR system will be disabled, and additional monitoring will be suspended for the remainder of the driving cycle, until the next engine start-up.

| EGR Stepper Monitor Electrical Check Operation: | |
|---|---|
| DTCs | P0403 |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | |
| Monitoring Duration | 4 seconds to register a malfunction |

| Stepper motor electrical check entry conditions: |
|---|
| Battery voltage > 11.0 volts |

| Typical EGR electrical check malfunction thresholds: |
|---|
| “Smart” Coil Output Driver status indicates open or short to ground, or short to power |

EGR flow is monitored using an analog Manifold Absolute Pressure Sensor (MAP). If a malfunction has been detected in the MAP sensor, the EGR monitor will not perform the EGR flow test.

The MAP sensor is checked for opens, shorts, or out-of-range values by monitoring the analog-to-digital (A/D) input voltage.

| MAP Sensor Check Operation | |
|---|---|
| DTCs | P0107 (low voltage), P0108 (high voltage) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| MAP electrical check entry conditions: |
|---|
| Battery voltage > 11.0 volts |

| Typical MAP sensor check malfunction thresholds: |
|---|
| Voltage < 0.024 volts or voltage > 4.96 volts |

The MAP sensor is also checked for rational values. The value of inferred MAP is checked against the actual value of MAP at idle and non-idle engine operating conditions.

| MAP Sensor Rationality Check Operation | |
|---|---|
| DTCs | P0106 |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical MAP Rationality check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Change in load | | 5% |
| Engine rpm | 500 rpm | 1800 rpm |

| Typical MAP Rationality check malfunction thresholds: |
|---|
| Difference between inferred MAP and actual MAP > 10 in Hg |

The MAP sensor is also checked for intermittent MAP faults.

| MAP Sensor Intermittent Check Operation | |
|---|---|
| DTCs | P0109 (non-MIL) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 2 seconds to register a malfunction |

| Typical MAP Intermittent check malfunction thresholds: |
|---|
| Voltage < 0.024 volts or voltage > 4.96 volts |

When EGR is delivered into the intake manifold, intake manifold vacuum is reduced and thus manifold absolute pressure (MAP) is increased. A MAP sensor and inferred MAP are used by this monitor to determine how much EGR is flowing. A MAP sensor located in the intake manifold measures the pressure when EGR is being delivered and when EGR is not being delivered. The pressure difference between EGR-on and EGR-off is calculated and averaged. If the vehicle also has a MAF sensor fitted, then the monitor also calculates and averages an inferred MAP value in the above calculation and resulting average. After a calibrated number of EGR-on and EGR-off cycles are taken, the measured and inferred MAP values are added together and compared to a minimum threshold to determine if a flow failure (P0400) in the EGR system has occurred.

| EGR Flow Check Operation: | |
|---|---|
| DTCs | P0400 |
| Monitor execution | once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | CPS, ECT, IAT, MAF, MAP (P0106/7/8), TP, BARO not available yet |
| Monitoring Duration | 200 seconds (600 data samples) |

| Typical EGR flow check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine RPM | 1400 rpm | 2600 rpm |
| Inferred Ambient Air Temperature | 32 °F | 140 °F |
| Engine Coolant Temperature | 80 °F | 250 °F |
| Engine RPM Steady (change/0.050 sec) | | 100 rpm |
| MAP Steady (change/0.050 sec) | | 0.5 in Hg |
| Engine Load Steady (change/0.050 sec) | | 1.5 % |
| BARO | 22.5 " Hg | |
| Intake Manifold Vacuum | 9.0 "Hg | 16.0 "Hg |
| Vehicle Speed | 35 MPH | 70 MPH |
| Engine Throttle Angle steady(absolute change) | 0.0 degrees | 4.0 degrees |

| Typical EGR flow check malfunction thresholds: |
|---|
| < 1.0 MAP differential |

| J1979 Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | Units |
| $33 | $82 | Normalized MAP differential (range 0 – 2) (P0400) | unitless |

## I/M Readiness Indication

If the inferred ambient temperature is less than 20 °F, greater than 130 °F, or the altitude is greater than 8,000 feet (BARO < 22.5 "Hg), the EGR flow test cannot be reliably done. In these conditions, the EGR flow test is suspended and a timer starts to accumulate the time in these conditions. If the vehicle leaves these extreme conditions, the timer starts decrementing, and, if conditions permit, will attempt to complete the EGR flow monitor. If the timer reaches 800 seconds, the EGR flow test is disabled for the remainder of the current driving cycle and the EGR Monitor I/M Readiness bit will be set to a “ready” condition after one such driving cycle. Two such consecutive driving cycles are required for the EGR Monitor I/M Readiness bit to be set to a "ready" condition.

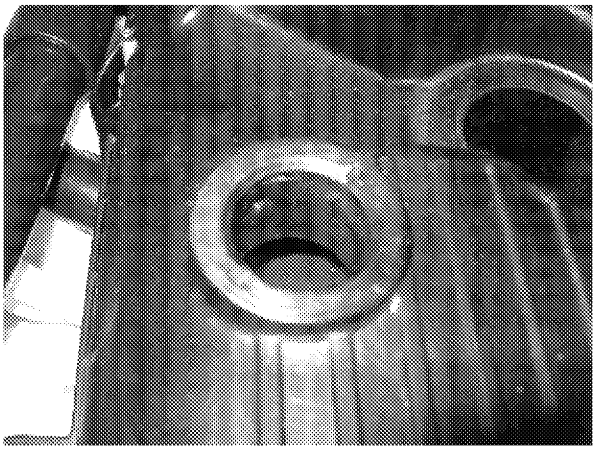
[redacted]

# PCV System Monitor

The PCV valve is installed into the rocker cover using a quarter-turn cam-lock design to prevent accidental disconnection. The PVC valve is connected to the intake manifold hose using a quick connect. Because the PCV valve has locking tabs and cannot be removed from the rocker cover without the use of special removal tools, the quick connect will be disconnected first in the event vehicle service is required. Molded plastic lines are typically used from the PCV valve to the intake manifold. The diameter of the lines and the intake manifold have been increased to 0.625" so that inadvertent disconnection of the lines after a vehicle is serviced will cause either an immediate engine stall or will not allow the engine to be restarted. In the event that the vehicle does not stall if the line between the intake manifold and PCV valve is inadvertently disconnected, the vehicle will have a large vacuum leak that will cause a Mass Air Flow equipped vehicle to run lean at idle. This will illuminate the MIL after two consecutive driving cycles and will store one or more of the following codes: Lack of O2 sensor switches, Bank 1 (P2195), Lack of O2 sensor switches Bank 2 (P2197), Fuel System Lean, Bank 1 (P0171),, Fuel System Lean, Bank 2 (P0174)

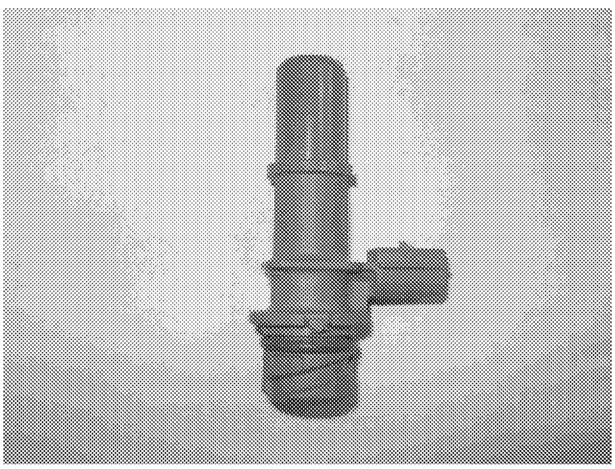
The PCV valve may incorporate a heater on some applications. A heated PCV valve is shown below. The PCV valve is designed to last for the life of the vehicle and should not require servicing or replacement.

Rocker cover with nub for quarter-turn valve

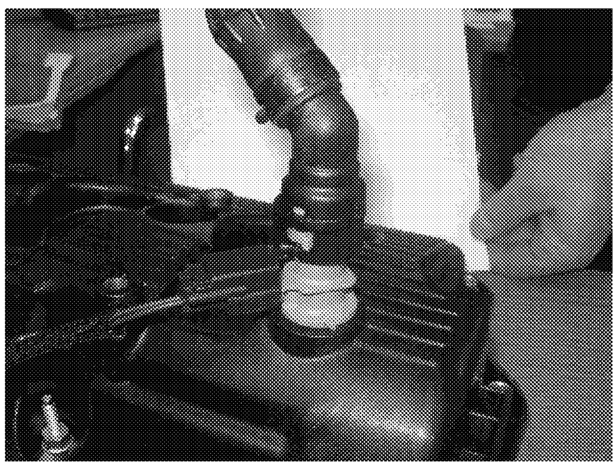


PCV hose with quick connect

Heater quarter-turn PCV valve with heater



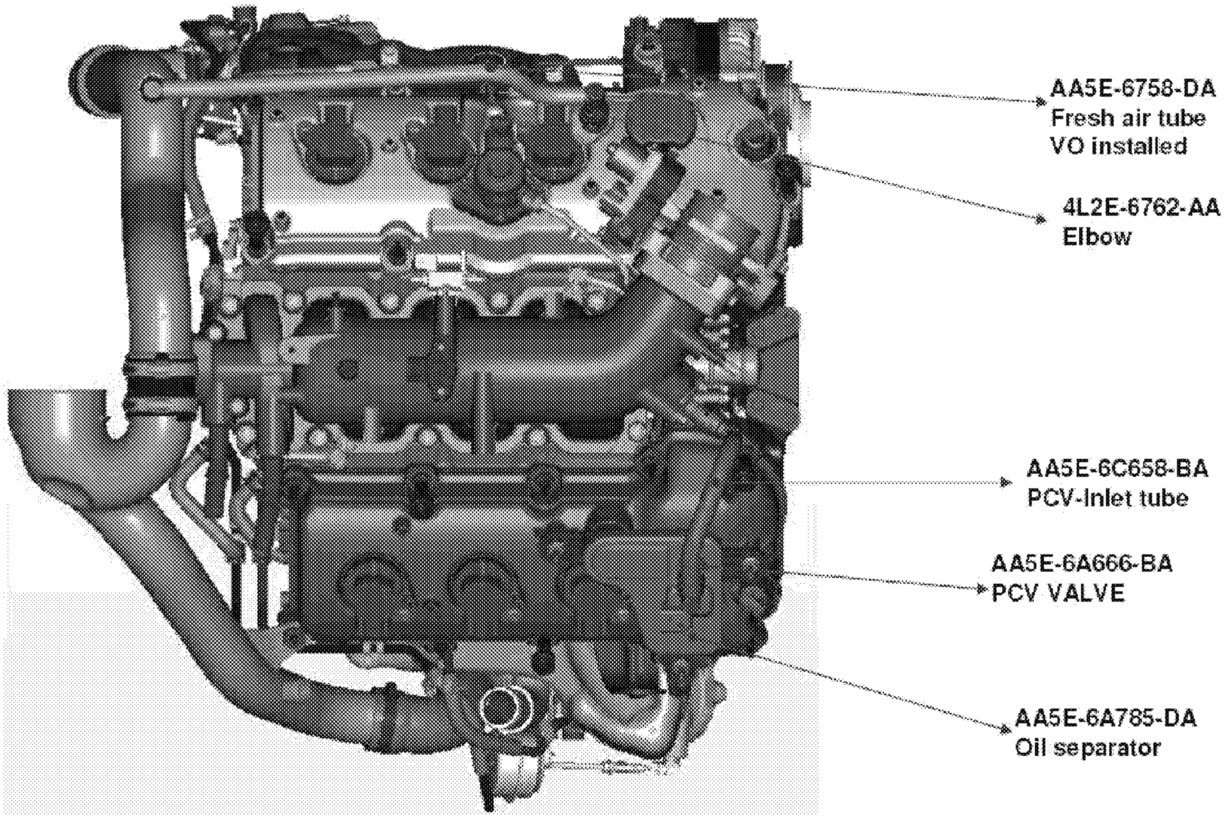
Assembled PCV system



## PCV System Monitor (GTDI With Speed Density)

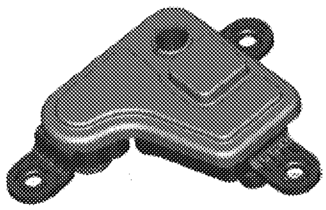
The PCV Inlet Tube has a no-tool quick disconnect on either end. Disconnection causes a 10.92 mm diameter leak into the intake manifold from atmosphere. The idle speed control is largely under control if an intake manifold leak exists. A persistent intake manifold leak would simply increase fuel consumption at idle and raise the engine idle speed slightly. A disconnection in the PCV inlet tube is made detectable by insuring that if it is disconnected a large (detectable) leak results. The PCV valve is semi-permanently affixed to the external oil separator. Both right and left valve covers contain internal oil separators. Overcoming the toque provided by the locking tabs allows removal via a ¼ turn. It is replaceable, but needs to be "torqued out" of the assembly. Mechanically, the hose is easy to disconnect (detectable disconnection) and the PCV valve is difficult to disconnect (undetectable disconnection).

The detection method compares engine air flow rate as computed from the speed density air charge calculation with the throttle air flow rate. Should the air entering the engine exceed the air through the throttle by a threshold amount, a leak is detected.

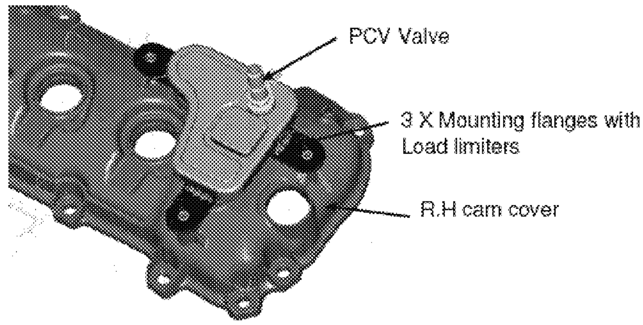





ED_002078G_00001212-00140



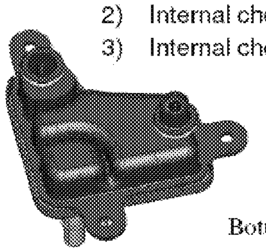
Oil separator



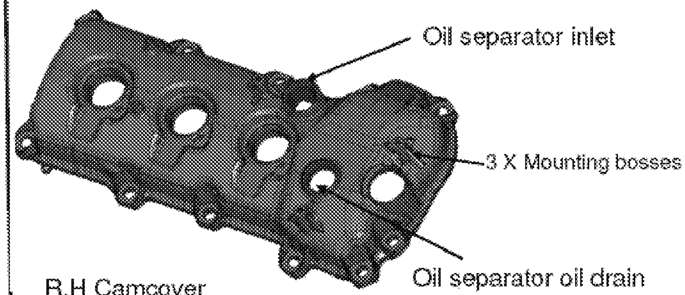


Features:

1) Internal pressure relief valve
2) Internal check valve (manifold side)
3) Internal check valve (Oil drain side)



Bottom view





R.H Camcover

| PCV M onitor Operation | |
|---|---|
| DTCs | P2282 - Air Leak Between Throttle Body and Intake Valve |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | N/A |
| Sensors OK | No fault is present in any of the sensors or systems affecting the PCV monitor. BARO sensor, MAP sensor, throttle charge temperature sensor, throttle inlet pressure sensor, manifold charge temperature sensor, no VCT malfunction |

| Typical P2282 check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Throttle angle (at condition for 300 msec minimum) | N/A | 4 deg |
| Intake Air Temp | -20 deg. F. | |
| Engine coolant temperature | -20 deg. F. | |
| Barometric pressure | 20 in. Hg. | |

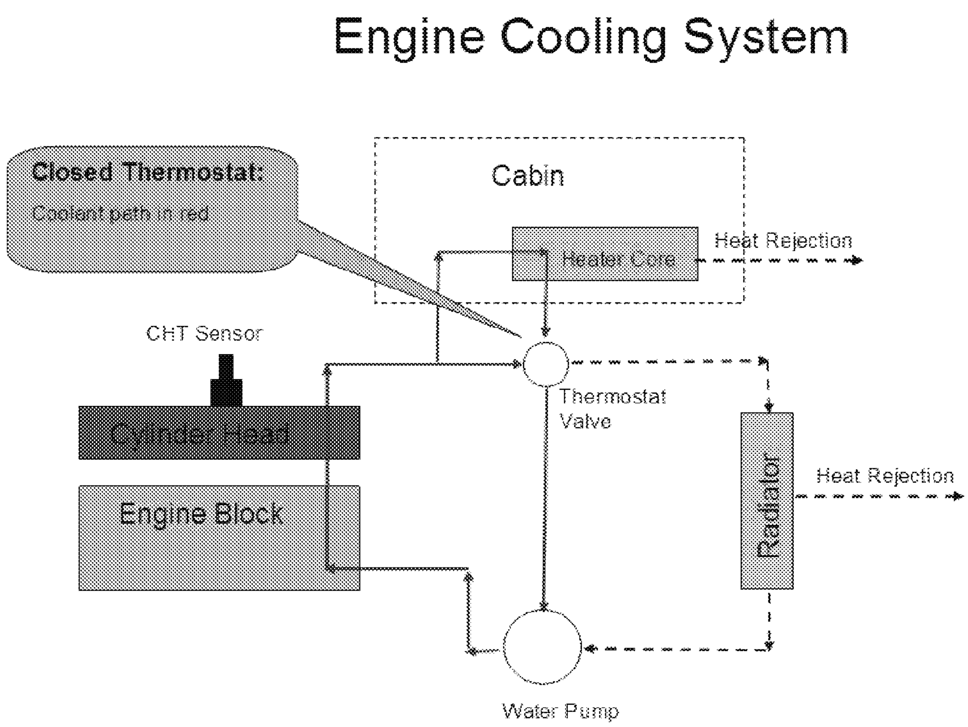
| Typical P2282 malfunction thresholds: |
|---|
| Calculated air leak of 1 lbm/min or greater that persists for at least 5 seconds. |

## Enhanced Thermostat Monitor

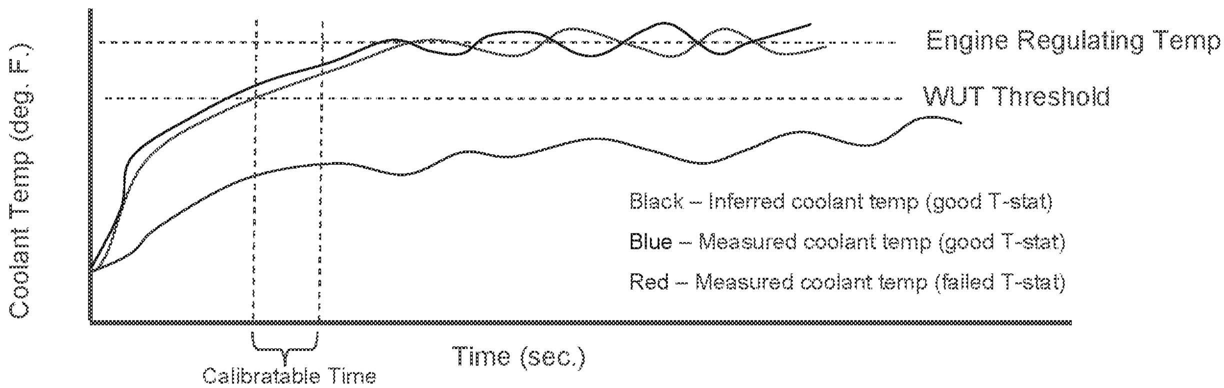
For the 2009 MY, the thermostat test has been enhanced to reduce the time it takes to identify a malfunctioning thermostat. The enhanced monitor includes a model which infers engine coolant temperature.

During a cold start, when the thermostat should be closed, the monitor uses a model of ECT to determine whether actual ECT should have crossed the Warm Up Temperature (WUT) threshold. The engine coolant temperature warm-up model compensates for the following thermal characteristics:

1. Coolant heating (heat source):
    - Combustion heating (engine speed and load based).
    - Cooling system heaters (electric or fuel-fired - new for 2013 MY)
2. Coolant cooling (heat sink):
    - Due to cylinder cut-out (DFSO or powertrain limiting).
        - Injectors are cut but still pumping air through the engine. Increased cooling compared to engine shut-down.
    - Due to engine shut-down. (Stop/Start and Hybrid – new for 2013 MY).
3. Coolant flow rate:
    - Mechanical water pumps have been replaced on some applications with clutched water pumps or electric water pumps.




Once the ECT model exceeds the WUT threshold, after a calibratable time delay, measured ECT is compared to the same WUT threshold to determine if ECT has warmed up enough. If ECT has warmed up to at least the WUT threshold, the thermostat is functioning properly. If ECT is too low, the thermostat is most likely stuck open and a P0128 is set.




The WUT threshold is normally set to 20 degrees F below the thermostat regulating temperature.

There are some circumstances that could lead to a false diagnosis of the thermostat. These are conditions where the vehicle cabin heater is extracting more heat than the engine is making. One example where this can occur is on large passenger vans which have "dual" heaters, one heater core for the driver and front passengers and another heater core for the passengers in the rear of the vehicle. At very cold ambient temperatures, even a properly functioning thermostat may never warm up to regulating temperature. Another example is a vehicle that is started and simply sits at idle with the heater on high and the defroster fan on high.

There are two features that are used to prevent a false thermostat diagnosis. For vehicles with dual heaters, the WUT threshold is reduced at cold ambient temperatures below 50 deg F. For cases where the engine is not producing sufficient heat, a timer is used to track time at idle or low load conditions (e.g. decels). If the ratio of time at idle/low load versus total engine run time exceeds 50% at the time the fault determination is made, the thermostat diagnostic does not make a fault determination for that driving cycle, i.e. "no-call".

| THERMOSTAT MONITOR OPERATION | |
|---|---|
| DTC | P0128 - Coolant Thermostat (Coolant temperature below thermostat regulating temperature) |
| Monitor Execution | Once per driving cycle, during a cold start |
| Monitoring Duration | Drive cycle dependent. Monitor completes in less than 300 seconds, when inferred ECT exceeds threshold (at 70 deg F ambient temperature) |

| TYPICAL THERMOSTAT MONITOR ENTRY AND COMPLETION CONDITIONS | | |
|---|---|---|
| Entry conditions | Minimum | Maximum |
| Engine Coolant Temperature at start | None | 125 °F |
| Intake Air Temperature at start (ambient temp) | 20 °F | None |
| Inferred Percent Ethanol (flex fuel vehicles only) | Learned | N/A |
| Completion condition | Minimum | Maximum |
| Modeled ECT | 172 °F | None |
| Time Since Modeled ECT Exceeded WUT Threshold | 300 sec. | None |
| Time at Idle/Low Load Compared with Total Engine Run Time | None | 50% |

| TYPICAL MALFUNCTION THRESHOLD |
|---|
| Engine Coolant Temperature < 172 °F (for a typical 192 °F thermostat) |

## Cold Start Emission Reduction Component Monitor

The Cold Start Emission Reduction Component Monitor was introduced for the 2006 MY on vehicles that meet the LEV-II emission standards. The monitor works by validating the operation of the components of the system required to achieve the cold start emission reduction strategy, namely retarded spark timing, and elevated idle airflow or VCT cam phasing.

The spark timing monitor was replaced by the Cold Start Emission Reduction System monitor in the 2007 MY. Changes to the OBD-II regulations, however, require having both a CSER system monitor and a CSER component monitor for the 2010 MY. The 2010 MY component monitor is not the same test that was introduced for the 2006 MY; rather, it has been redesigned.

### Low Idle Airflow Monitor – Systems with Electronic Throttle Control

When the CSER strategy is enabled, the Electronic Throttle Control system will request a higher idle rpm, elevating engine airflow. Vehicles that have ETC and do not have a separate airflow test (P050A). Any fault that would not allow the engine to operate at the desired idle rpm during a cold start would be flagged by one of three ETC DTCs:

P2111 (throttle actuator control system stuck open),
P2112 throttle actuator control system stuck closed)
P2107 (throttle actuator control module processor/circuit test).

All three DTCs will illuminate the MIL in 2 driving cycles, and immediately illuminate the "ETC" light. These DTCS are also documented in the ETC section of this document.

For the 2009 MY, only the Fusion/Milan utilizes the CSER Component monitor with ETC.

| Throttle Plate Controller and Actuator Operation: | |
|---|---|
| DTCs | P2107 – processor test (MIL)<br>P2111 – throttle actuator system stuck open (MIL)<br>P2112 – throttle actuator system stuck closed (MIL)<br>Note: For all the above DTCs, in addition to the MIL, the ETC light will be on for the fault that caused the FMEM action. |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 60 msec for processor fault, 500 msec for stuck open/closed fault |

| Throttle Plate Controller and Actuator malfunction thresholds: |
|---|
| P2111 - Desired throttle angle vs. actual throttle angle > 6 degrees |
| P2112 - Desired throttle angle vs. actual throttle angle < 6 degrees |
| P2107 - Internal processor fault, lost communication with main CPU |

## Engine Speed and Spark Timing Component Monitor (2010 MY and beyond)

### Entry Conditions and Monitor Flow

The System Monitor and 2010 Component Monitor share the same entry conditions and monitor flow. During the first 15 seconds of a cold start, the monitor checks the entry conditions, counts time in idle, observes catalyst temperature, calculates the average difference between desired and actual engine speed, and calculates the average difference between desired and commanded spark.

If the expected change in catalyst temperature is large enough, the monitor then begins the waiting period, which lasts until 300 seconds after engine start. This 5-minute wait allows time to diagnose other components and systems that affect the validity of the test. During this waiting period, there are no constraints on drive cycle and the monitor cannot be disabled without turning off the key.

If the System monitor result falls below its threshold and all of the Component monitor results are below their respective thresholds, the monitor determines whether the idle time was sufficient. If so, it considers the tests a pass and the monitor is complete. If idle time was not sufficient, the monitor does not make a pass call and does not complete. This prevents tip-ins from resulting in false passes.

### Cold Start Engine Speed Monitor

Once the waiting period is complete, the monitor compares the average difference between desired and actual engine speeds to a calibratable threshold that is a function of ECT at start. If the magnitude of the discrepancy exceeds the threshold, P050A is set.

### Cold Start Spark Timing Monitor

Once the waiting period is complete, the monitor compares the average difference between desired and commanded spark to a calibratable threshold that is a function of ECT at start. If the magnitude of the discrepancy exceeds the threshold, P050B is set.

| CSER COMPONENT MONITOR OPERATION | |
|---|---|
| Component Monitor DTCs | P050A: Cold Start Idle Air Control System Performance<br>P050B: Cold Start Ignition Timing Performance |
| Monitor Execution | Once per driving cycle, during a cold start |
| Monitor Sequence | Monitor data collection takes place during first 15 seconds of cold start |
| Sensors OK | No fault is present in any of the sensors or systems affecting the catalyst temperature model: Mass Air Flow (P0102, P0103), Throttle Position (P0122, P0123, P0222, P0223), Misfire (P0316, P0300-P0312), Injectors (P0201-P0212), Fuel System (P0171, P0172, P0174, P0175), Secondary Air (P0412, P2258), Crank Position Sensor (P0320), Ignition Coil (P0351-P0360), Intake Air Temp (P0112, P0113), Engine Coolant Temp/Cylinder Head Temp (P0117, P0118, P1289, P1290), Variable Cam Timing (P0010, P0020, P0011, P0012, P0021, P0022), Intake Manifold Runner Control (P2008). |
| Monitoring Duration | Monitor completes 300 seconds after initial engine start |

| TYPICAL CSER COMPONENT MONITOR ENTRY AND COMPLETION CONDITIONS | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Barometric Pressure | 22 in. Hg | |
| Engine Coolant Temperature at Start | 35 °F | 100 °F |
| Catalyst Temperature at Start | 35 °F | 125 °F |
| Fuel Level | 15% | |
| No Torque Reduction by Injector Cutout | | |
| Power Takeout Not Active | | |
| Completion condition | Minimum | Maximum |
| Length of Time Entry Conditions are Satisfied | 11 sec. | |
| Expected Change in Catalyst Temperature | 50 °F | |
| Time in Idle | 10 sec. | |
| Selected Gear | Neutral | Drive |

| TYPICAL CSER COMPONENT MONITOR MALFUNCTION THRESHOLDS |
|---|
| Engine speed discrepancy > 200 rpm |
| Spark timing discrepancy > 10 deg. |

## Cold Start Variable Cam Timing Monitor (2008 MY and beyond)

If the VCT cam phasing is used during a cold start to improved catalyst heating, the VCT system is checked functionally by monitoring the closed loop cam position error correction. If the proper cam position cannot be maintained and the system has an advance or retard error greater than the malfunction threshold, a cold start emission reduction (CSER) VCT control malfunction is indicated (P052A/P052B (Bank 1), P052C/P052D (Bank2). This test is the same test that was used previously for monitoring the VCT system under Comprehensive Component Monitoring requirements.

| CSER VCT Target Error Check Operation:] | |
|---|---|
| DTCs | P052A – Cold start camshaft position timing over-advanced (Bank 1)<br><br>P052B – Cold start camshaft timing over-retarded (Bank 1)<br><br>P052C – Cold start camshaft timing over-advanced (Bank 2)<br><br>P052D – Cold start camshaft timing over-retarded (Bank 2) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 5 seconds |

| Typical CSER VCT target error entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| VCT control enabled and commanded to advance or retard cam during CSER | n/a | n/a |
| Time since start of CSER cam phase monitoring | | 60 seconds |

| Typical CSER VCT target error malfunction thresholds: |
|---|
| CSER Response/target error - VCT over-advance: 11 degrees<br><br>CSER Response/target error - VCT over-retard: 11 degrees<br><br>CSER Response/Stuck Pin – 10 degrees phasing commanded, and not seeing at least 2 degrees of movement. |

# Cold Start Emission Reduction System Monitor

The Cold Start Emission Reduction System Monitor is being introduced for the 2007 MY on vehicles that meet the LEV-II emission standards. The System Monitor detects the lack of catalyst warm up resulting from a failure to apply sufficient CSER during a cold start. It does this by using the inferred catalyst temperature model to determine how closely the actual catalyst temperature follows the expected catalyst temperature during a cold start. How closely the actual temperature follows the expected temperature is reflected in a ratio which is compared with a calibratable threshold.

## Temperatures Used

The actual catalyst temperature is the same inferred catalyst temperature that is used by other portions of the engine control system, including the CSER control system. The inputs to this actual temperature are measured engine speed, measured air mass, and commanded spark.

The expected catalyst temperature is calculated using the same algorithm as the actual catalyst temperature, but the inputs are different. Desired engine speed replaces measured engine speed, desired air mass replaces measured air mass, and desired cold start spark replaces commanded spark. The resulting temperature represents the catalyst temperature that is expected if CSER is functioning properly.

## Ratio Calculation

A ratio is calculated to reflect how closely the actual temperature has followed the expected temperature. This ratio is the difference between the two temperatures at a certain time-since-start divided by the increase in expected temperature over the same time period. The ratio, then, provides a measure of how much loss of catalyst heating occurred over that time period.

This ratio correlates to tailpipe emissions. Therefore applying a threshold to it allows illumination of the MIL at the appropriate emissions level. The threshold is a function of ECT at engine start.

## General CSER Monitor Operation

During the first 15 seconds of a cold start, the monitor checks the entry conditions, counts time in idle, and observes catalyst temperature.

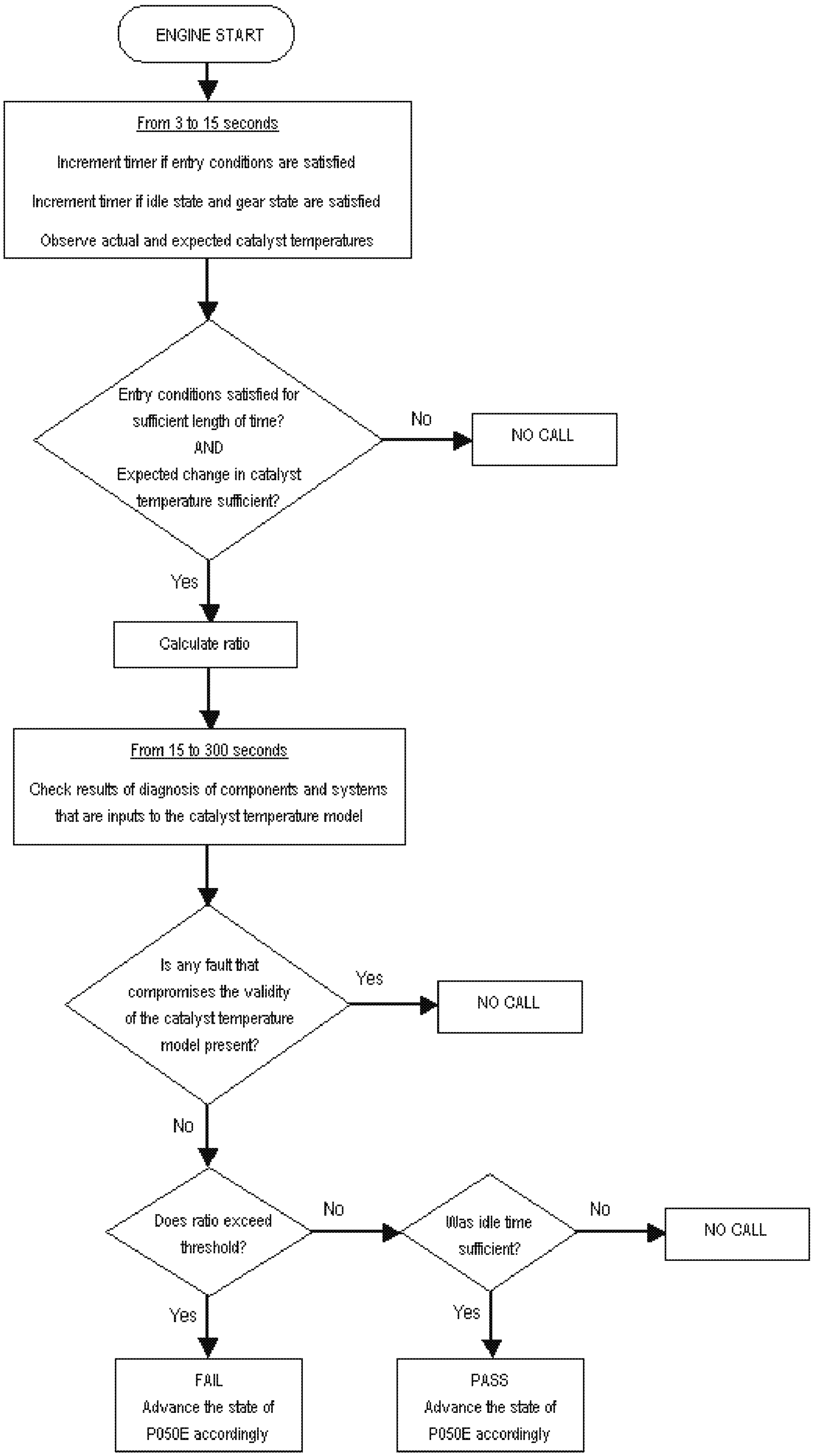
If the expected change in catalyst temperature is large enough, the monitor calculates the ratio as described above. Otherwise the monitor does not make a call.

The monitor then begins the waiting period, which lasts from the time the ratio is calculated (15 seconds after engine start) until 300 seconds after engine start. This 5-minute wait allows time to diagnose other components and systems that affect the validity of the catalyst temperature model. During this waiting period, there are no constraints on drive cycle and the monitor cannot be disabled without turning off the key.

At the end of the waiting period, if no other faults that could compromise the validity of the catalyst temperature model are found, the monitor compares the ratio to the threshold.

If the ratio exceeds the threshold, the monitor considers the test a fail, and the monitor is complete.

If the ratio falls below the threshold and all of the component monitor results are below their respective thresholds, the monitor determines whether the idle time was sufficient. If so, it considers the test a pass and the monitor is complete. If idle time was not sufficient, the monitor does not make a pass call and does not complete. This prevents tip-ins from resulting in false passes.


ENGINE START
From 3 to 15 seconds
Increment timer if entry conditions are satisfied
Increment timer if idle state and gear state are satisfied
Observe actual and expected catalyst temperatures
Entry conditions satisfied for sufficient length of time?
AND
Expected change in catalyst temperature sufficient?
No
NO CALL
Yes
Calculate ratio
From 15 to 300 seconds
Check results of diagnosis of components and systems that are inputs to the catalyst temperature model
Is any fault that compromises the validity of the catalyst temperature model present?
Yes
NO CALL
No
Does ratio exceed threshold?
No
Was idle time sufficient?
No
NO CALL
Yes
Yes
FAIL
Advance the state of P050E accordingly
PASS
Advance the state of P050E accordingly

| CSER SYSTEM MONITOR OPERATION | |
|---|---|
| System Monitor DTC | P050E: Cold Start Engine Exhaust Temperature Too Low |
| Monitor Execution | Once per driving cycle, during a cold start |
| Monitor Sequence | Monitor data collection takes place during first 15 seconds of cold start |
| Sensors OK | No fault is present in any of the sensors or systems affecting the catalyst temperature model: Mass Air Flow (P0102, P0103), Throttle Position (P0122, P0123, P0222, P0223), Misfire (P0316, P0300-P0312), Injectors (P0201-P0212), Fuel System (P0171, P0172, P0174, P0175), Secondary Air (P0412, P2258), Crank Position Sensor (P0320), Ignition Coil (P0351-P0360), Intake Air Temp (P0112, P0113), Engine Coolant Temp/Cylinder Head Temp (P0117, P0118, P1289, P1290), Variable Cam Timing (P0010, P0020, P0011, P0012, P0021, P0022), Intake Manifold Runner Control (P2008). |
| Monitoring Duration | Monitor completes 300 seconds after initial engine start |

| TYPICAL CSER SYSTEM MONITOR ENTRY AND COMPLETION CONDITIONS | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Barometric Pressure | 22 in. Hg | |
| Engine Coolant Temperature at Start | 35 °F | 100 °F |
| Catalyst Temperature at Start | 35 °F | 125 °F |
| Fuel Level | 15% | |
| No Torque Reduction by Injector Cutout | | |
| Power Takeout Not Active | | |
| Completion condition | Minimum | Maximum |
| Length of Time Entry Conditions are Satisfied | 11 sec. | |
| Expected Change in Catalyst Temperature | 50 °F | |
| Time in Idle | 10 sec. | |
| Selected Gear | Neutral | Drive |

| TYPICAL CSER SYSTEM MONITOR MALFUNCTION THRESHOLDS |
|---|
| Cold start warm-up temperature ratio > 0.4 |

# Variable Cam Timing System Monitor

Variable Cam Timing (VCT) enables rotation of the camshaft(s) relative to the crankshaft (phase-shifting) as a function of engine operating conditions. There are four possible types of VCT with DOHC engines:

- Intake Only (phase-shifting only the intake cam);
- Exhaust Only (phase-shifting only the exhaust cam);
- Dual Equal (phase-shifting the intake and exhaust cams equally);
- Twin Independent (phase-shifting the intake and exhaust cams independently).

All four types of VCT are used primarily to increase internal residual dilution at part throttle to reduce NOx, and to improve fuel economy. This allows for elimination the external EGR system.

With Exhaust Only VCT, the exhaust camshaft is retarded at part throttle to delay exhaust valve closing for increased residual dilution and to delay exhaust valve opening for increased expansion work.

With Intake Only VCT, the intake camshaft is advanced at part throttle and WOT (at low to mid-range engine speeds) to open the intake valve earlier for increased residual dilution and close the intake valve earlier in the compression stroke for increased power. When the engine is cold, opening the intake valve earlier warms the charge which improves fuel vaporization for less HC emissions; when the engine is warm, the residual burned gasses limit peak combustion temperature to reduce NOx formation.

With Dual Equal VCT, both intake and exhaust camshafts are retarded from the default, fully advanced position to increase EGR residual and improve fuel economy by reducing intake vacuum pumping losses. The residual charge for NOx control is obtained by backflow through the late-closing exhaust valve as the piston begins its intake stroke.

The VCT system hardware consists of a control solenoid and a pulse ring on the camshaft. The PCM calculates relative cam position using the CMP input to process variable reluctance sensor pulses coming from the pulse ring mounted on the camshaft. Each pulse wheel has N + 1 teeth where N = the number of cylinders per bank. The N equally spaced teeth are used for cam phasing; the remaining tooth is used to determine cylinder # 1 position. Relative cam position is calculated by measuring the time between the rising edge of profile ignition pickup (PIP) and the falling edges of the VCT pulses.

The PCM continually calculates a cam position error value based on the difference between the desired and actual position and uses this information to calculate a commanded duty cycle for the VCT solenoid valve. When energized, engine oil is allowed to flow to the VCT unit thereby advancing and retarding cam timing. The variable cam timing unit assembly is coupled to the camshaft through a helical spline in the VCT unit chamber. When the flow of oil is shifted from one side of the chamber to the other, the differential change in oil pressure forces the piston to move linearly along the axis of the camshaft. This linear motion is translated into rotational camshaft motion through the helical spline coupling. A spring installed in the chamber is designed to hold the camshaft in the low-overlap position when oil pressure is too low (~15 psi) to maintain adequate position control. The camshaft is allowed to rotate up to 30 degrees.

Although the VCT system has been monitored under Comprehensive Component Monitoring requirements for many years, a new, emission-based VCT monitor is being introduced for the 2006 MY on vehicles that meet LEV-II emission standards. The intent of the new VCT monitoring requirements is to detect slow VCT system response that could cause emissions to increase greater than 1.5 * std. in addition to detecting functional problems (target errors).

The new logic calculates the instantaneous variance in actual cam position (the squared difference between actual cam position and commanded cam position), then calculates the long term variance using a rolling average filter (Exponentially Weighted Moving Average). Continued, slow response from the VCT system will eventually accumulate large variances.

This same logic will also detect target errors that were detected by the previous CCM monitor. If the VCT system is stuck in one place, the monitor will detect a variance which will quickly accumulate.

There are two variance indices, one that monitors cam variance in the retard direction and the other for the advance direction,. If either variance index is greater than the malfunction threshold, a VCT slow response/target error malfunction will be indicated (P0011, P0012, P0014, P0015 Bank 1, P0021, P0022, P0024, P0025 Bank 2). Target errors will tend to generate only a single over-advanced or over-retarded code while slow response will tend to generate both codes.

In addition, logic has been added to determine whether the camshaft and crankshaft are misaligned by one or more teeth. This test calculates the absolute offset between one of the camshaft teeth and the crankshaft missing tooth at idle when that can is at its stop. If the error is greater than the malfunction threshold, a cam/crank misalignment error will be indicated (P0016 Bank 1, P0018 Bank 2).

For systems that phase the cams immediately off of a cold start for reducing emissions or CSER (Cold Start Emissions Reduction) the cam position is monitored for functionality during this period of time. The logic calculates the instantaneous variance in actual cam position (the squared difference between actual cam position and commanded cam position), then calculates a longer term variance using a rolling average filter (Exponentially Weighted Moving Average) This is similar to the target error logic described above, but uses separate time constants and thresholds. There are two variance indices, one that monitors cam variance in the retard direction and the other for the advance direction,. If either variance index is greater than the malfunction threshold, a VCT slow response/target error malfunction will be indicated (P052A, P052B, P054A, P054B (Bank 1), P052C, P052D, P054C, P054D (Bank 2). Target errors will tend to generate only a single over-advanced or over-retarded code while slow response will tend to generate both codes.

The in-use performance ratio numerator for the VCT monitor can be incremented only if the VCT system has been monitored for both functional and response faults.

Similar to the previous CCM monitor, the VCT solenoid output driver in the PCM is checked electrically for opens and shorts (P0010 Bank 1, P0020 Bank 2).

| VCT Monitor Operation: | |
|---|---|
| DTCs | P0010 - Camshaft Position Actuator Circuit (Bank 1)<br><br>P0011 - Intake Camshaft Position Timing - Over-Advanced (Bank 1)<br><br>P0012 - Intake Camshaft Position Timing - Over-Retarded (Bank 1)<br><br>P0014 - Exhaust Camshaft Position Timing - Over-Advanced (Bank 1)<br><br>P0015 - Exhaust Camshaft Position Timing - Over-Retarded (Bank 1)<br><br>P0016 - Crank/Cam Position Correlation (Bank 1)<br><br>P0020 - Camshaft Position Actuator Circuit (Bank 2)<br><br>P0021 - Intake Camshaft Position Timing - Over-Advanced (Bank 2)<br><br>P0022 - Intake Camshaft Position Timing - Over-Retarded (Bank 2)<br><br>P0024 - Exhaust Camshaft Position Timing - Over-Advanced (Bank 2)<br><br>P0025 - Exhaust Camshaft Position Timing - Over-Retarded (Bank 2)<br><br>P0018 – Crank/Cam Position Correlation (Bank 2) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | IAT, ECT, EOT, IMRC, TP, MAF, CKP, and CMP |
| Monitoring Duration | 5 - 10 seconds for circuit faults and functional checks, 300 - 900 seconds for target error |

| Typical VCT response/functional monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine RPM (for P0016/P0018 only) | 500 | 4500 |
| Engine Coolant Temperature | 35 - 50 $^{o}$F | |
| Engine Oil Temperature | | 280 $^{o}$F |
| VCT control enabled and commanded to advance or retard cam ** | n/a | n/a |
| ** VCT control of advance and retard by the engine is disabled in crank mode, when engine oil is cold (< 150 $^{o}$F), while learning the cam/crank offset, while the control system is "cleaning" the solenoid oil passages, throttle actuator control in failure mode, and if one of the following sensor failures occur: IAT, ECT, EOT, MAF, TP, CKP, CMP, or IMRC. | | |

| Typical VCT monitor malfunction thresholds: |
|---|
| VCT solenoid circuit: Open/short fault set by the PCM driver |
| Cam/crank misalignment: > or = one tooth difference, or 16 crank degrees |
| Response/target error - VCT over-advance variance too high: 40 to 700 degrees squared |
| Response/target error - VCT over-retard variance too high: 40 to 700 degrees squared |
| Response/target error - Cam bank-to-bank variance too high: 40 to 700; degrees squared |

**J1979 VCT Monitor Mode $06 Data**

| Monitor ID | Test ID | Description for CAN | Units |
|---|---|---|---|
| $35 | $80 | Camshaft Advanced Position Error Bank 1 (P011/P0014) | Unsigned, Angular degrees |
| $35 | $81 | Camshaft Retarded Position Error Bank 1 (P0012/P0015) | Unsigned, Angular degrees |
| $36 | $80 | Camshaft Advanced Position Error Bank 2 (P0021/P0024) | Unsigned, Angular degrees |
| $36 | $81 | Camshaft Retarded Position Error Bank 2 (P0022/P0025) | Unsigned, Angular degrees |

[redacted]

# Gasoline Direct Injection

Ford is adding gasoline Direct Injection (DI) to many of its engines for improved fuel economy, performance and emissions. Most engines will also incorporate a turbocharger when they go to DI, however, some engines will not. Engines with turbo charging are designated as GTDI (Gasoline Turbo Direct Injection) and engine without turbo charging are designated GDI (Gasoline Direct Injection).

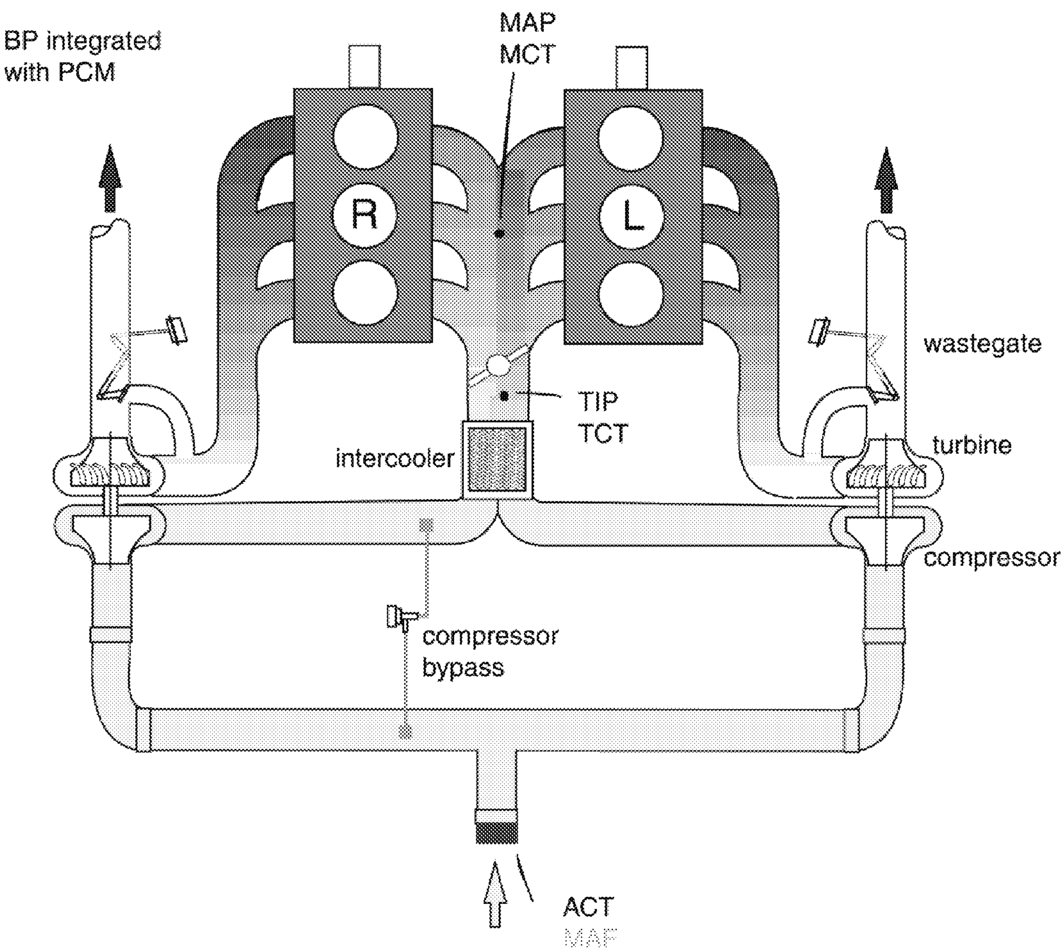
The fuel systems for both of these variants are very similar. The only difference is that the GDI engine does not have the turbo controls that consist of the Turbocharger, Wastegate Control Valve, Compressor Bypass Valve and the sensor that contains the Throttle Inlet Pressure Sensor (TCB-A) and Throttle Charge Temperature Sensor (CACT)

Ford's first GTDI engine was introduced in the 2010 MY. The 3.5 L GTDI engine was based off the 3.5L IVCT engine used in the Taurus, Edge, etc. The GTDI version was introduced in the 2010 MY Ford Flex, Lincoln MKR (CUV), Taurus and Lincoln MKS (sedan).

The PCM for the GTDI engine controls the following sensors and actuators:

Outputs/Actuators: Electronic Throttle Control, Variable Cam Timing (Intake only), Wastegate Control Valve, Compressor Bypass Valve, Ignition timing, Fuel injectors (Direct Injection), Fuel Rail Pressure Control Valve

Inputs/Sensors: MAP, Manifold Charge Temp, Throttle Inlet Pressure, Throttle Charge Temp, Intake Air Temp, BARO, Cylinder Head Temp, Cam & Throttle positions, Engine Speed, Fuel Rail Pressure, UEGO (front, control), HEGO (rear fuel trim)



For the 2011 MY, 3.5L/3.7L engine was upgraded from ICVT (Intake-only Variable Cam Timing) to TIVCT (Twin Independent Variable Cam Timing. The 3.5L GTDI engine in the F-150 is based off this upgraded engine (3.5L GTDI TIVCT). The DI and turbo controls, however, are unchanged.

For the 2011 MY, the Explorer will be available with a 2.0L GTDI engine with TIVCT. For 2012 MY, it is also available in the Edge. The DI and turbo controls are similar to the 3.5L GTDI with the exception that there is only one turbocharger.

For the 2012 MY, the Focus will be available with a 2.0L GDI engine with TIVCT. The controls are similar to the 2.0L GTDI engine. The only difference is that the GDI engine does not have the turbo controls that consist of the Turbocharger, Wastegate Control Valve, Compressor Bypass Valve and the sensor that contains the Throttle Inlet Pressure Sensor (TCB-A) and Throttle Charge Temperature Sensor (CACT)

Because GDI engine controls and OBD are a subset of the GDTI engine controls and OBD, they will all be described in this chapter.

## Intake Air Temperature 1 Sensor (IAT1)

The Intake Air Temperature 1 sensor (also called Air Charge Temperature) is used for the inference of ambient temperature for several PCM strategy features. In previous designs, the Intake Air Temperature 1 sensor was physically integrated with the Mass Air Flow (MAF) sensor. In this design, the Intake Air Temperature 1 sensor is a stand-alone sensor and is mounted near the air cleaner.

| Intake Air Temperature 1 Sensor Circuit Range Check | |
|---|---|
| DTCs | P0112 Intake Air Temperature Sensor 1 Circuit Low (Bank 1)<br>P0113 Intake Air Temperature Sensor 1 Circuit High (Bank 1) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Intake Air Temperature 1 Sensor Circuit Range Check Malfunction Thresholds |
|---|
| P0112 IAT1 voltage < 0.244 volts<br>P0113 IAT1 voltage > 4.96 volts |

| Intake Air Temperature Sensor 1 Circuit Intermittent Check | |
|---|---|
| DTCs | P0114 Intake Air Temperature Sensor 1 Intermittent/Erratic (Bank 1) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | counts intermittent events per trip |

| Typical Air Charge Temperature Sensor Check Malfunction Thresholds |
|---|
| 10 intermittent out-of-range events per driving cycle |

## Charge Air Cooler Temperature Sensor (CACT)

The Charge Air Cooler Temperature sensor (also known as Throttle Charge Temperature) refines the estimate of air flow rate through the throttle.

| Throttle Charge Temperature Sensor Circuit Range Check | |
|---|---|
| DTCs | P007C Charge Air Cooler Temperature Sensor Circuit Low (Bank 1)<br>P007D Charge Air Cooler Temperature Sensor Circuit High (Bank 1) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Throttle Charge Temperature Sensor Circuit Range Check Malfunction Thresholds |
|---|
| P007C CACT voltage < 0.244 volts<br>P007D CACT voltage > 4.96 volts |

## Intake Air Temperature 2 Sensor (IAT2)

The Intake Air Temperature 2 sensor (also known as Manifold Charge Temperature) is mounted to the intake manifold and is used to compute cylinder air charge and provide input for various spark control functions. It is integrated with the intake manifold pressure sensor.

| Manifold Charge Temperature Sensor Circuit Range Check | |
|---|---|
| DTCs | P0097 Intake Air Temperature Sensor 2 Circuit Low (Bank 1)<br>P0098 Intake Air Temperature Sensor 2 Circuit High (Bank 1) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Manifold Charge Temperature Sensor Circuit Range Malfunction Thresholds |
|---|
| P0097 IAT2 voltage < 0.244 volts<br>P0098 IAT2 voltage > 4.96 volts |

| IAT1, CACT, IAT2, EOT Temperature Sensor Transfer Function | | |
|---|---|---|
| **Volts** | **A/D counts in PCM** | **Temperature, degrees F** |
| 4.89 | 1001 | -40 |
| 4.86 | 994 | -31 |
| 4.81 | 983 | -22 |
| 4.74 | 970 | -13 |
| 4.66 | 954 | -4 |
| 4.56 | 934 | 5 |
| 4.45 | 910 | 14 |
| 4.30 | 880 | 23 |
| 4.14 | 846 | 32 |
| 3.95 | 807 | 41 |
| 3.73 | 764 | 50 |
| 3.50 | 717 | 59 |
| 3.26 | 666 | 68 |
| 3.00 | 614 | 77 |
| 2.74 | 561 | 86 |
| 2.48 | 508 | 95 |
| 2.23 | 456 | 104 |
| 1.99 | 407 | 113 |
| 1.77 | 361 | 122 |
| 1.56 | 319 | 131 |
| 1.37 | 280 | 140 |
| 1.20 | 246 | 149 |
| 1.05 | 215 | 158 |
| 0.92 | 188 | 167 |
| 0.80 | 165 | 176 |
| 0.70 | 144 | 185 |
| 0.61 | 126 | 194 |
| 0.54 | 110 | 203 |
| 0.47 | 96 | 212 |
| 0.41 | 85 | 221 |
| 0.36 | 74 | 230 |
| 0.32 | 65 | 239 |
| 0.28 | 57 | 248 |
| 0.25 | 51 | 257 |
| 0.22 | 45 | 266 |
| 0.19 | 40 | 275 |
| 0.17 | 35 | 284 |
| 0.15 | 31 | 293 |
| 0.14 | 28 | 302 |

## IAT1, CACT, IAT2 Key-Up Correlation Check

Once the IAT1, CACT, IAT2 are confirmed to be in-range, the key-up correlation test compares the three temperatures on key-up after a long period off key-off time (6 hours). The three-way correlation test is run only once per power-up.

After a long key-off period, the three temperature sensors are expected to report nearly the same temperature. The exception to this is when a block heater is used. Block heater use can cause these three air temperature sensors to widely differ from each other. To detect if an engine coolant heater is active we compare Cylinder Head Temperature (CHT) to Transmission Fluid Temperature (TFT). A significant temperature difference (10°F) indicates block heater activity.

The IAT, CACT, and IAT2 are mounted along the engine air intake system.

- The IAT is mounted in the engine air inlet (near air cleaner).
- The CACT is mounted near the throttle inlet.
- The IAT2 is mounted inside the intake manifold.

If the sensors all agree, no malfunction is indicated and the test is complete. Specifically, the three way check compares 3 sensor pairings. All three pairings must correlate to pass this test.

- IAT and CACT agree within a tolerance (±30°F) and
- CACT and IAT2 agree within a tolerance (±30°F) and
- IAT2 and IAT agree within a tolerance (±30°F).

**Case 1** At least two correlation pairings are within tolerance (±30°F). All sensors pass.

**Case 2** One correlation pairing is within tolerance (±30°F). Those two sensors that correlate pass, the third sensor is flagged as faulted.

**Case 3** Zero correlation pairings are within tolerance (±30°F). P00CE Intake Air Temperature Measurement System – Multiple Sensor Correlation

| Engine Air Temperature Sensor Key-Up Correlation Check | |
|---|---|
| DTCs | P0111 Intake Air Temperature Sensor 1 Circuit Range/Performance (Bank 1)<br>P007B Charge Air Cooler Temperature Sensor Circuit Range/Performance (Bank 1)<br>P0096 Intake Air Temperature Sensor 2 Circuit Range/Performance (Bank 1)<br>P00CE Intake Air Temperature Measurement System – Multiple Sensor Correlation |
| Monitor execution | Once per driving cycle, at start-up |
| Monitor Sequence | None |
| Sensors OK | ECT/CHT, IAT1, CACT, IAT2, TFT |
| Monitoring Duration | Immediate |

| Engine Air Temperature Sensor Key-Up Correlation Check Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine off (soak) time | 6 hours | |
| CHT – TFT at start (block heater inferred) | | +10 °F |

| Typical Engine Air Temperature Sensor Key-Up Correlation Check Malfunction Thresholds |
|---|
| CHT at least 10°F hotter than TFT means block heater detected. |

## IAT1, CACT, IAT2 Out of Range Hot Check

The IAT1, CACT, IAT2 are all checked for maximum expected temperature readings during a steady state driving condition. When parked at hot ambient temperatures or after heavy load operation, these temperatures can climb to unusually high temperatures thus the "too hot" check is not done at those conditions.

| Engine Air Temperature Sensor Out of Range Hot Check | |
|---|---|
| DTCs | P0111 Intake Air Temperature Sensor 1 Circuit Range/Performance (Bank 1)<br>P007B Charge Air Cooler Temperature Sensor Circuit Range/Performance (Bank 1)<br>P0096 Intake Air Temperature Sensor 2 Circuit Range/Performance (Bank 1) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ECT/CHT, IAT, VSS |
| Monitoring Duration | 250 seconds to register a malfunction |

| Engine Air Temperature Sensor Out of Range Hot Check Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Vehicle speed | 40 mph | |
| Time above minimum vehicle speed (if driving req'd) | 5 min | |
| For IAT1, Load below a maximum load threshold | 1.0 | |

| Typical Engine Air Temperature Sensor Out of Range Hot Check Malfunction Thresholds |
|---|
| P0111 IAT1 > 150°F<br>P007B CACT > 220°F<br>P0096 IAT2 > 240°F |

## Barometric Pressure Sensor (BARO)

The Barometric Pressure Sensor (BARO) is used to directly measure barometric pressure and for exhaust back pressure estimation. (Exhaust back pressure influences speed density based air charge computation.) The BARO sensor is directly mounted to the PCM circuit board.

The BARO sensor has a high accuracy operating range of 60 to 115 kPa (17.7 to 34.0 "Hg) and a full operating range of 7.6 to 121.6 kPa. The voltage is electrically clipped between 0.3 and 4.8 volts.

A P2228 or P2229 DTC indicates that either the sensor is electrically faulted or the sensed barometric pressure is outside the normal operating range.

| BARO Sensor Transfer Function | | |
|---|---|---|
| Vout=Vref * (0.007895 * Pressure (in kPa) | | |
| Volts | Pressure, kPa | Pressure, Inches Hg |
| 0.3 | 7.6 | 2.2 |
| 0.5 | 12.7 | 3.8 |
| 2.638 | 60 | 17.7 |
| 4.54 | 115 | 34.0 |
| 4.75 | 120.3 | 35.5 |
| 4.8 | 121.6 | 35.9 |

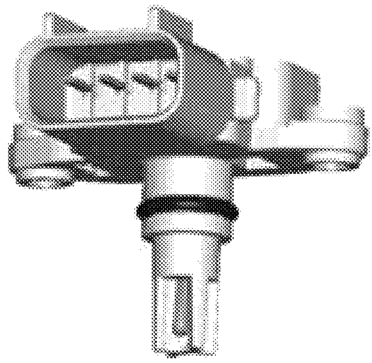
| Barometric Pressure Sensor Range Check | |
|---|---|
| DTCs | P2228 Barometric Pressure Circuit Low<br>P2229 Barometric Pressure Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Barometric Pressure Sensor Range Check Malfunction Thresholds |
|---|
| P2228 BP < 2.0 volts (above 15,000 ft altitude)<br>P2229 BP > 4.4 volts (below -1,000 ft altitude) |

## Turbocharger Boost Sensor A (TCB-A)

The Turbocharger Boost Sensor A (also known as Throttle Inlet Pressure (TIP)) is the feedback sensor for turbo boost control. Boost control algorithm computes desired boost from operating conditions and adjusts the pneumatically-controlled boost pressure limit to achieve that desired boost pressure. TCB-A is also used to compute air flow rate through the throttle independently of the primary air charge computation for torque monitoring (and intake manifold leak detection).

The TCB-A sensor is physically integrated with the Charge Air Cooler Temperature Sensor. The boost sensor has a specified range of 20 to 300 kPa. The voltage is electrically clipped between 0.3 to 4.8 volts,



| TCB-A and MAP Sensor Transfer Function | | |
|---|---|---|
| Vout=(Vref / 5) * (0.0146428 * Pressure (in kPa) + 0.1072) | | |
| Volts | Pressure, kPa | Pressure, Inches Hg |
| 0.3 | 13.16 | 3.89 |
| 0.4 | 20 | 5.91 |
| 0.986 | 60.0 | 17.72 |
| 2.157 | 140 | 41.34 |
| 3.329 | 220.0 | 64.97 |
| 4.5 | 300 | 88.59 |
| 4.8 | 320.49 | 94.64 |

| Throttle Inlet Pressure Sensor Range Circuit Check | |
|---|---|
| DTCs | P0237 Turbocharger/Supercharger Boost Sensor A Circuit Low<br>P0238 Turbocharger/Supercharger Boost Sensor A Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Throttle Inlet Pressure Sensor Range Circuit Check Malfunction Thresholds |
|---|
| P0237 TCB-A voltage < 0.19 volts<br>P0238 TCB_A voltage > 4.88 volts |

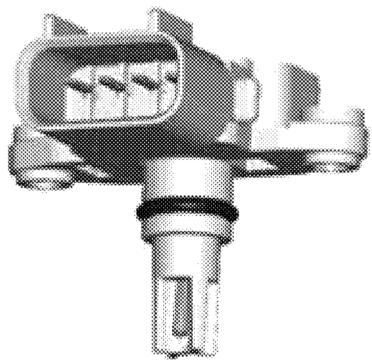
| Throttle Inlet Pressure Sensor Range Circuit Intermittent Check | |
|---|---|
| DTCs | P025E Turbocharger/Supercharger Boost Sensor "A" Intermittent/Erratic |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | counts intermittent events per trip |

| Typical Throttle Inlet Pressure Sensor Range Circuit Malfunction Thresholds |
|---|
| 10 intermittent out-of-range events per driving cycle |

## Intake Manifold Pressure (MAP) Sensor

The Manifold Absolute Pressure (MAP) sensor is used for the Speed Density air charge calculation.

The MAP sensor is physically integrated with the Intake Air Temperature 2 sensor. The MAP sensor has a specified range of 10 to 200 kPa. The voltage is electrically clipped between 0.3 to 4.8 volts,



| TCB-A nd MAP Sensor Transfer Function | | |
|---|---|---|
| Vout=Vref * (0.0044736 * Pressure (in kPa) + 0.035263) | | |
| Volts | Pressure, kPa | Pressure, Inches Hg |
| 0.3 | 5.53 | 1.63 |
| 0.40 | 10.0 | 2.95 |
| 1.630 | 65.0 | 19.19 |
| 2.301 | 95.0 | 28.05 |
| 3.643 | 155.0 | 45.77 |
| 4.65 | 200.0 | 59.06 |
| 4.8 | 206.71 | 61.04 |

| Intake Manifold Pressure Sensor Range Circuit Check | |
|---|---|
| DTCs | P0107 Manifold Absolute Pressure/BARO Sensor Low<br>P0108 Manifold Absolute Pressure/BARO Sensor High |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Intake Manifold Pressure Sensor Range Circuit Check Malfunction Thresholds |
|---|
| P0107 MAP voltage < 0.19 volts<br>P0108 MAP voltage > 0.4.88 volts |

| Intake Manifold Pressure Sensor Range Circuit Intermittent Check | |
|---|---|
| DTCs | P0109 Manifold Absolute Pressure/BARO Sensor Intermittent |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | counts intermittent events per trip |

| Typical Intake Manifold Pressure Sensor Range Circuit Malfunction Thresholds |
|---|
| 10 intermittent out-of-range events per driving cycle |

## BARO, TCB-A, MAP Sensor 3-Way Correlation Check at Key-Up

At key-up BARO, TCB-A, and MAP are compared. If any two agree and one does not, that sensor is declared faulted.

| BP, TIP, MAP Sensor 3-Way Correlation Check at Key-Up | |
|---|---|
| DTCs | P2227 P0236 P0106 Barometric Pressure Circuit Range/Performance |
| Monitor execution | At key-up |
| Monitor Sequence | None |
| Sensors OK | BP, MAP, TIP |
| Monitoring Duration | 0.2 seconds |

| BP, TIP, MAP Sensor 3-Way Correlation Check at Key-Up Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine off (soak) time | 10 seconds | |
| Battery Voltage | 6.75 volts | |

| Typical BP, TIP, MAP Sensor 3-Way Correlation Check at Key-Up Malfunction Thresholds |
|---|
| \|TCB-A – MAP\| < 2.72"Hg<br>\|BARO – MAP\| < 2.03"Hg<br>\|BARO – TCB-A\| < 2.14"Hg |

## BARO, TCB-A and TCB-A, MAP Sensor 2-Way Correlation Check

Should a BARO, TCB-A, or MAP sensor pass the key-on test but become faulted during operation, two air pressure sensor correlation check are made.

- At low engine air flows no turbocharger boost is commanded and BARO should be very close to TCB-A.
- In certain operation regions, MAP can be estimated from TCB-A, throttle angle, and engine speed (a.k.a. speed-throttle).

These two correlations are then used to infer if any of the three air pressure sensors are faulted

| BARO, TCB-A Sensor 2-Way Correlation Check Entry | |
|---|---|
| DTCs | P2227 Barometric Pressure Sensor "A" Circuit Range/Performance<br>P0236 Turbocharger/Supercharger Boost Sensor "A" Circuit Range/Performance<br>P0106 Barometric Pressure Circuit Range/Performance |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | BP, TIP, MAP |
| Monitoring Duration | 10 seconds |

| BARO, TCB-A Sensor 2-Way Correlation Check Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Low TP | | 4.0° |
| Low engine rpm | | 1500 rpm |

| Typical BARO, TCB-A Sensor 2-Way Correlation Check Entry Malfunction Thresholds | |
|---|---|
| pass | (\|BARO – TCB-A\| < 5.5"Hg) AND (\|MAP – Estimated MAP\| < 3.5"Hg) |
| P2227 | (\|BARO – TCB-A\| > 5.5"Hg) AND (\|MAP – Estimated MAP\| < 1.8"Hg) |
| P0106 | (\|BARO – TCB-A\| < 1.8"Hg) AND (\|MAP – Estimated MAP\| > 3.5"Hg) |
| P0236 | (if none of above conditions met) |

## Compressor Bypass Valve(s)

The compressor bypass valve(s) is used to prevent backflow though the turbocharger compressors when the throttle is rapidly closed to avoid an undesirable audible noise. The high pressure downstream of the compressor bypasses the compressor as it travels upstream when the valve is open. In this application, two compressor bypass valves are used to establish a sufficient bypass flow rate. The compressor bypass valve(s) are checked for electrical faults.

| Compressor Bypass Valve Circuit Check Operation: | |
|---|---|
| DTCs | P0034 Turbocharger/Supercharger Bypass Valve "A" Control Circuit Low<br>P0035 Turbocharger/Supercharger Bypass Valve "A" Control Circuit High<br>P00C1 Turbocharger/Supercharger Bypass Valve "B" Control Circuit Low<br>P00C2 Turbocharger/Supercharger Bypass Valve "B" Control Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 5 seconds |

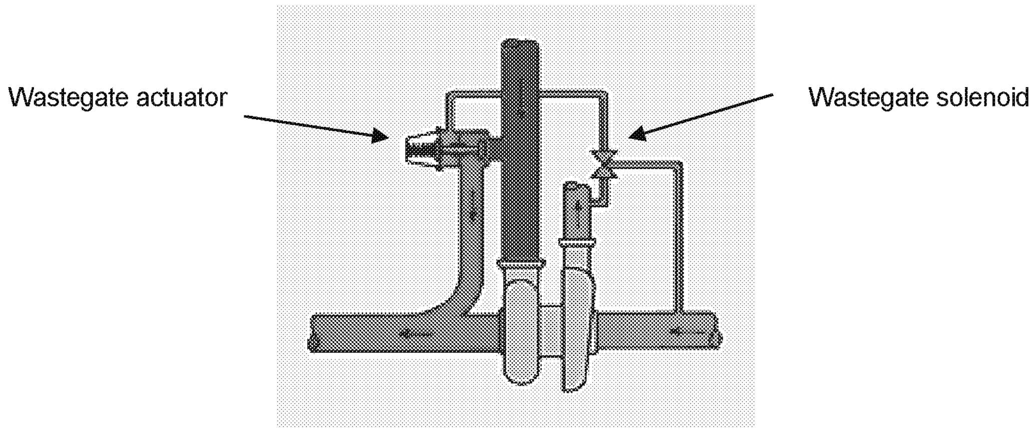
| Compressor Bypass Valve Circuit malfunction thresholds: |
|---|
| PCM smart driver hardware detects faults for circuit short to battery, short to ground, and open circuit. Fault status reported to PCM to set appropriate DTC. |

## Wastegate Pneumatic Solenoid Valve

The wastegate (one per turbocharger) allows exhaust pressure to bypass the turbocharger's turbine, to control compressor speed (on the same shaft), and thus boost pressure. The wastegate controller is actually a mechanical-pneumatic boost pressure controller. Its boost pressure limit can be increased within a limited range by altering the pressure "seen" by the pneumatic actuator. The wastegates are only controlled indirectly by the PCM via the wastegate pneumatic solenoid.

A high pressure on the wastegate actuator's diaphragm tends to open the wastegate. The solenoid valve normally connects compressor out pressure (boost) to the wastegate actuator's diaphragm, resulting in the regulation of maximum boost pressure (to a constant value). Using the wastegate vent solenoid to partially vent (reduce) that control pressure increases the regulated maximum boost.

As the compressor outlet pressure increases, a pneumatically powered actuator opens each turbocharger wastegate to limit compressor outlet pressure. The wastegate pneumatic solenoid valve modulates that feedback pressure to increase the boost pressure limit. A duty cycle of 100% vents feedback thus eliminating any wastegate controlled boost limit. A duty cycle of 0% results in the base boost limit of approximately 5 psi gauge.



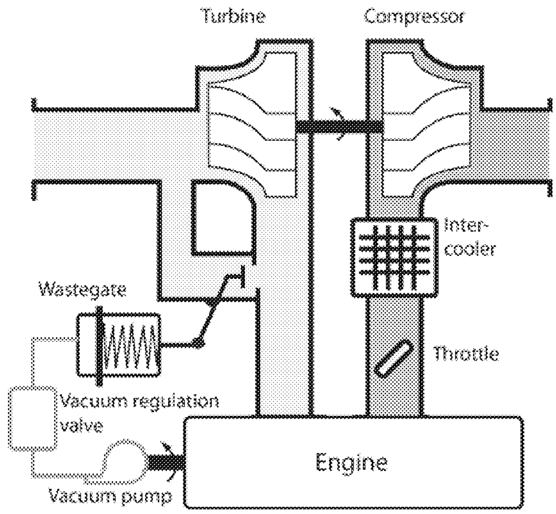

| Wastegate Pneumatic Solenoid Valve Circuit Check Operation | |
|---|---|
| DTCs | P0245 Turbocharger/Supercharger Wastegate Solenoid A Low<br>P0246 Turbocharger/Supercharger Wastegate Solenoid A High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 5 seconds |

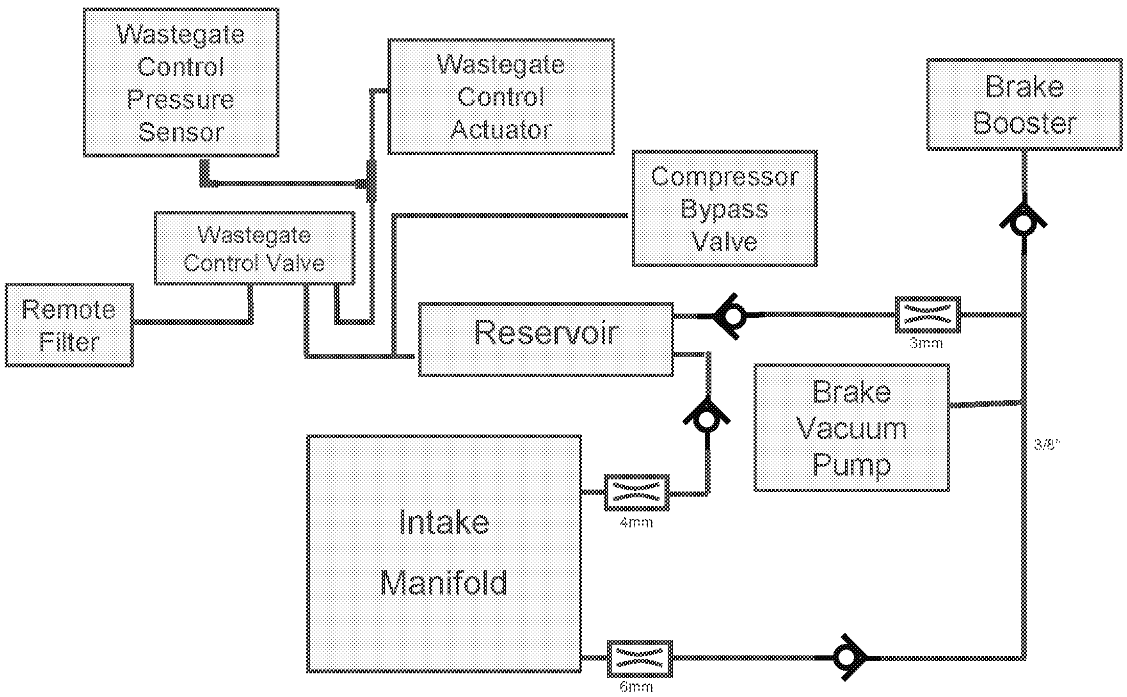
| Wastegate Pneumatic Solenoid Valve Circuit malfunction thresholds: |
|---|
| PCM smart driver hardware detects faults for circuit short to battery, short to ground, and open circuit. Fault status reported to PCM to set appropriate DTC. |

## Vacuum Actuated Wastegate System

The 3.5L GTDI was introduced with a mechanical-pneumatic boost pressure controller as described in the previous section. Boost pressure is limited mechanically via a diaphragm and spring. Boost pressure can be increased within a limited range by controlling a wastegate pneumatic solenoid.

The 2.0L GTDI was introduced with a vacuum actuated wastegate. This permits control of the wastegate position at all engine conditions. The wastegate can be opened at some part load conditions to reduce the backpressure on the engine. This reduces pumping losses and improves efficiency and fuel economy. A vacuum sensor was added to improve the accuracy and robustness of the control system.




2.0LGTDI (EcoBoost) Vacuum Schematic for Wastegate Control System

| Wastegate Pneumatic Solenoid Valve Circuit Check Operation | |
|---|---|
| DTCs | P0245 Turbocharger/Supercharger Wastegate Solenoid A Low<br>P0246 Turbocharger/Supercharger Wastegate Solenoid A High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 2 - 3 seconds |

| Wastegate Pneumatic Solenoid Valve Circuit malfunction thresholds: |
|---|
| PCM smart driver hardware detects faults for circuit short to battery, short to ground, and open circuit. Fault status reported to PCM to set appropriate DTC. |

Under steady conditions, the control pressure error should be small. Control pressure lower than expected could indicate an air leak between wastegate canister and the wastegate solenoid, and insufficient source of vacuum, or that the wastegate solenoid is stuck off. Control pressure higher than expected could indicate that the wastegate solenoid is stuck on

| Wastegate Control Pressure Check Operation | |
|---|---|
| DTCs | P1015 Wastegate Control Pressure Lower Than Expected<br>P1016 Wastegate Control Pressure Lower Than Expected |
| Monitor execution | Continuous |
| Sensors OK | No P100F, P1011, P1012, P1013, P0245, P0246 DTCs |
| Monitor Sequence | None |
| Monitoring Duration | 5 seconds |

| Wastegate Control Pressure Check Entry Conditions | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Desired wastegate control pressure is stable:<br>(desired pressure - expected pressure). | | 0.5 in Hg |

| Wastegate Pneumatic Solenoid Valve Circuit malfunction thresholds: |
|---|
| P1015 - Wastegate control pressure error > 3 in Hg<br>P1016 - Wastegate control pressure error > 5 in Hg |

## Wastegate Control Pressure Sensor

The wastegate control pressure sensor is checked for opens, short and intermittents, P1012, P1013 and P1014.

| Wastegate Control Pressure Sensor Check Operation | |
|---|---|
| DTCs | P1012 Wastegate Control Pressure Sensor Circuit Low<br>P1013 Wastegate Control Pressure Sensor Circuit High<br>P1014 Wastegate Control Pressure Sensor Circuit Intermittent/Erratic |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 5 seconds |

| Wastegate Control Pressure Sensor Transfer Function | | |
|---|---|---|
| Vout=(Vref / 5) * (0.04399 * Pressure (in kPa) - 0.140) | | |
| Volts | Pressure, kPa | Pressure, Inches Hg |
| 0.3 | 10.0 | 2.95 |
| 0.4 | 12.3 | 3.62 |
| 1.0 | 25.9 | 7.65 |
| 2.0 | 48.6 | 14.36 |
| 3.0 | 71.4 | 21.07 |
| 4.5 | 105.5 | 31.14 |
| 4.8 | 112.8 | 33.31 |

| Wastegate Control Pressure Sensor Check Entry Conditions | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| none | | |

| Wastegate Pneumatic Solenoid Valve Circuit malfunction thresholds: |
|---|
| P1012 – voltage < 0.20 V<br>P1013 – voltage > 4.93 V<br>P1014 – open or shorted > 10 events in a driving cycle |

The wastegate control pressure sensor reading is checked at key-up using a four-way correlation check. If the wastegate control pressure sensor reading is higher or lower than the readings of the BARO, MAP, and TIP, a P100F is set. .A P1011 is set if the wastegate control pressure is greater than BARO.

| Wastegate Control Pressure Sensor Check Operation | |
|---|---|
| DTCs | P1011 Wastegate Control Pressure Sensor Circuit Range/Performance<br>P100F Wastegate Control Pressure/BARO Correlation |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | No P1012, P1013, P1011, P2228, P2229, P2227, P0236, P0106 DTCs. |
| Monitoring Duration | 5 seconds |

| Wastegate Control Pressure Sensor Check Entry Conditions | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine off time (P100F only) | 20 sec | |

| Wastegate Pneumatic Solenoid Valve Circuit malfunction thresholds: |
|---|
| P100F – pressure error exceeds 2.5 in Hg<br>P1011 – pressure exceeds BARO by > 3.0 in Hg |

## Boost Control

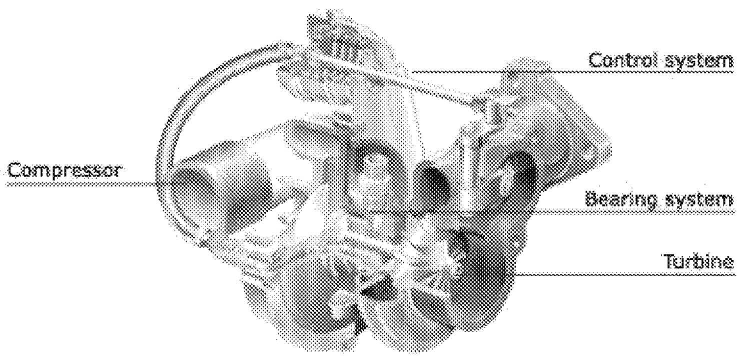
The boost control system determines a desired boost. Active control occurs when the desired boost is above base boost where base boost is defined as that boost that results when the wastegate vent solenoid is not venting (circuit off).

The following conditions may result in underboost.

- One or more wastegates stuck open
- Large conduit leak between compressor and throttle

The following conditions may result in overboost.

- One or more wastegates stuck closed
- One or more control hoses leaking/disconnected between wastegate diaphragm and wastegate vent solenoid.
- Wastegate vent solenoid stuck in vent position
- Control hoses to wastegate vent solenoid swapped.
- Hose between boost volume and wastegate vent solenoid disconnected.
- Not-yet-detected Turbocharger Boost sensor in-range failure.




The boost control system computes a desired boost based on operating conditions. Via the wastegate pneumatic solenoid valve, it varies the boost pressure limit to achieve its desired boost level (measured by the TCB-A sensor). The air charge control regulates the throttle to control the intake manifold pressure (MAP).

| OverBoost Control Functional Check Operation: | |
|---|---|
| DTCs | P0234 (Turbocharger/Supercharger A Overboost Condition) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors/Actuators OK | CBV, TCB-A, WGS, BARO |
| Monitoring Duration | 5 seconds (up/down timer) |

| OverBoost Control Functional Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Wastegate Duty Cycle | | 0.05 |

| OverBoost Control Functional Check Malfunction Thresholds: |
|---|
| (Boost Pressure Desired – Boost Pressure Actual) > 4 psi |

| UnderBoost Control Functional Check Operation: | |
|---|---|
| DTCs | P0299 (Turbocharger/Supercharger A Underboost Condition) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors/Actuators OK | CBV, TCB-A, WGS, BARO |
| Monitoring Duration | 5 seconds (up/down timer) |

| OverBoost Control Functional Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Wastegate Duty Cycle | 0.95 | |

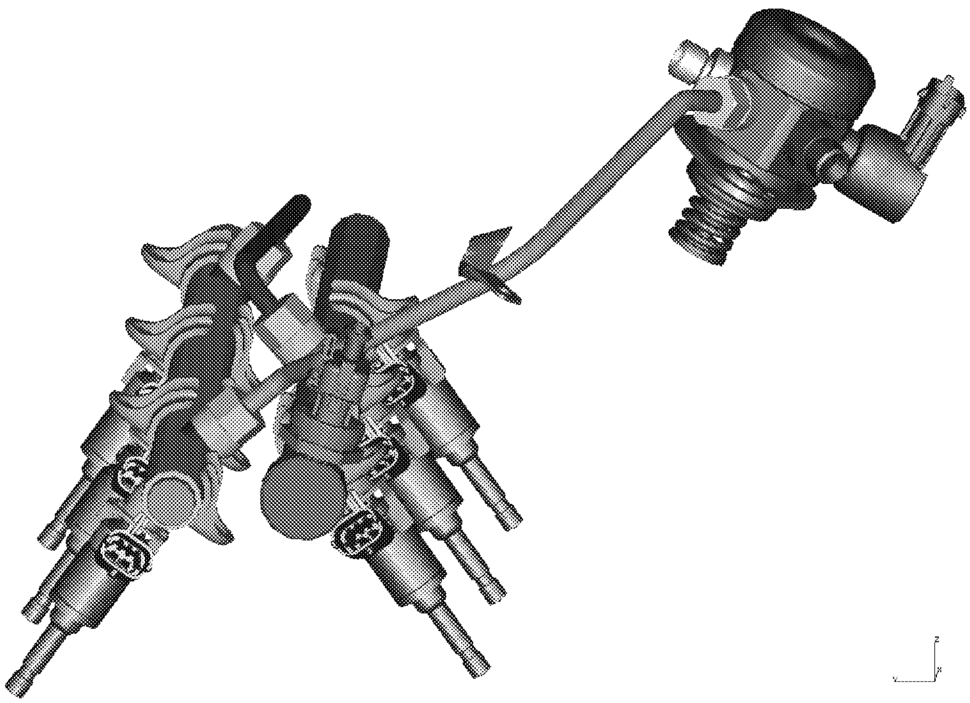
| OverBoost Control Functional Check Malfunction Thresholds: |
|---|
| –(Boost Pressure Desired – Boost Pressure Actual) > 4 psi |

## Fuel Injectors, Gasoline Direct Injection

### Overview

The Gasoline Direct Injection (GDI) system is similar to a Port Fuel Injection (PFI) system with the exception of an added high-pressure pump.

- An in-tank pump supplies 65 psi fuel to the high pressure, camshaft-driven pump.
- The PCM-controlled pump produces a selectable pressure in the fuel rail(s).
- On/off injectors meter the high pressure fuel directly into the cylinders.



GDI Fuel Injectors, Rail, and High Pressure Pump

Gasoline Direct Injection (GDI) injectors spray liquid fuel, under high pressure, directly in the cylinder when activated. The high pressure fuel is supplied to the injector by a common fuel rail. The desired fuel pressure is determined by the PCM. Fuel injector pulsewidth is based on actual fuel pressure which is measured by a pressure sensor in the common rail.

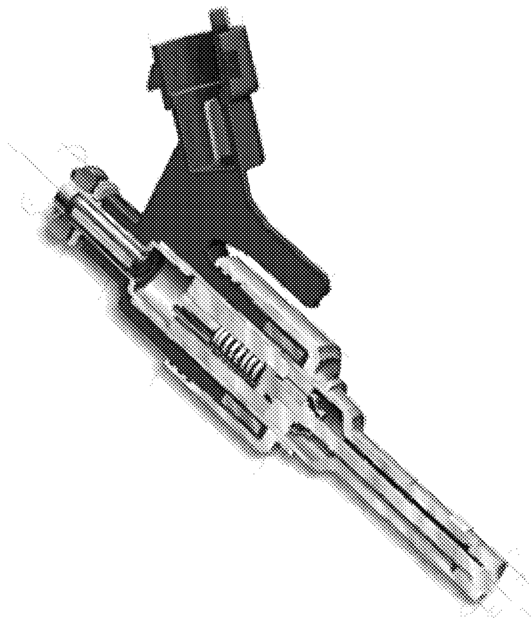
Injection typically occurs in the cylinder's intake and compression stroke. Under certain conditions, multiple injections can occur per cylinder event. Since injection pressure is variable, the fuel mass injected is a function of both fuel pressure and injector pulsewidth.

A typical PFI injector is activated by applying battery voltage to it. The GDI injector driver applies a high voltage (65 volts) to initially open the injector and then controls injector current to hold it open during injection.

## Fuel Injectors

A typical PFI injector is single side controlled by the PCM. The GDI injector has two wires per injector routed to the PCM. The injector high side goes to a PCM pin (or two pins) that are common between an injector pair. The PCM contains a smart driver that monitors and compares high side and low side injector currents to diagnose numerous faults. All injector fault modes, however, are mapped into a single DTC per injector.

A higher-than-battery-voltage supply (internally generated within the PCM) is used to open the injector and modulated battery voltage holds the injector open. The injector driver IC controls three transistor switches that apply the boost voltage and then modulate injector current. Should that full voltage be unavailable, the proper injector opening current may not be generated in the time required. This fault (P062D) is detected on a per cylinder basis and reported without specifying a particular cylinder.



GDI Fuel Injector

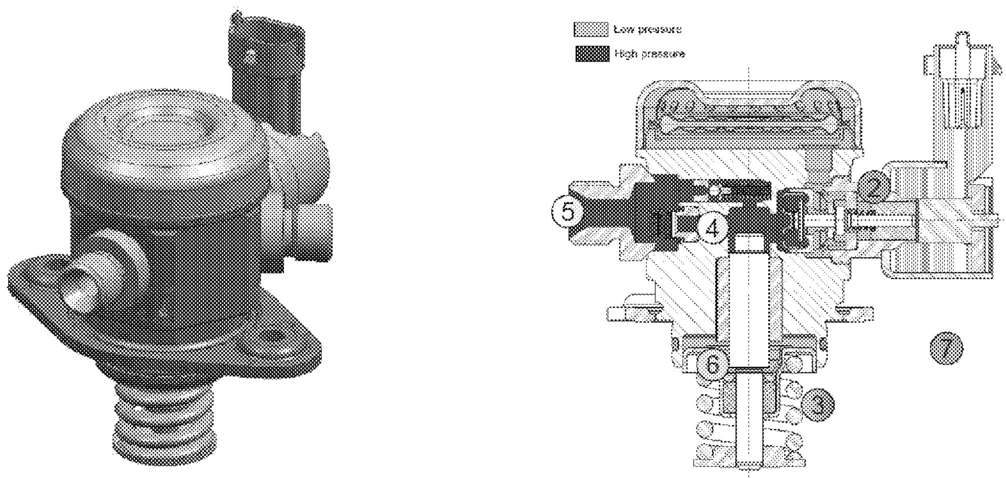
| Injector Circuit Check Operation | |
|---|---|
| DTCs | P0201 through P0206 (Cylinder x Injector Circuit)<br>P062D Fuel Injector Driver Circuit Performance |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Monitoring Duration | 10 seconds |

| Typical Injector Circuit Check Entry Conditions | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 11.0 volts | |

## Fuel Volume Regulator

The high pressure fuel pump raises Fuel Rail Pressure (FRP) to the desired level to support fuel injection requirements. Unlike Port Fuel Injection (PFI) systems, with Gasoline Direct Injection (GDI), the desired fuel rail pressure ranges widely over operating conditions.

The Fuel Volume Regulator is controlled to allow a desired fraction of the pump's full displacement (fuel volume) into the fuel rail. A fuel rail pressure control algorithm computes the required fraction of fuel pump volume to achieve the desired pressure. The high pressure fuel pump can only increase (and not reduce) fuel rail pressure. Fuel Injection is used to reduce fuel rail pressure.

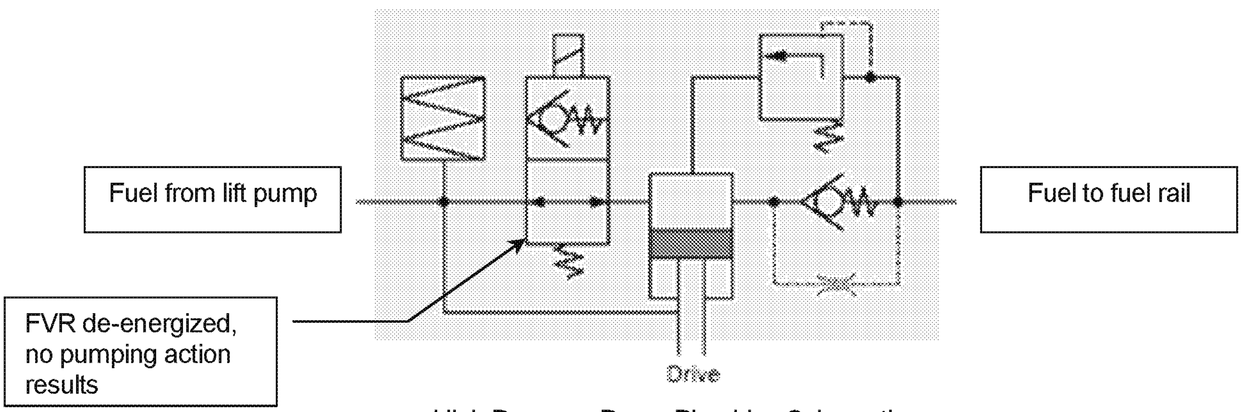


High Pressure Fuel Pump and Cutaway view

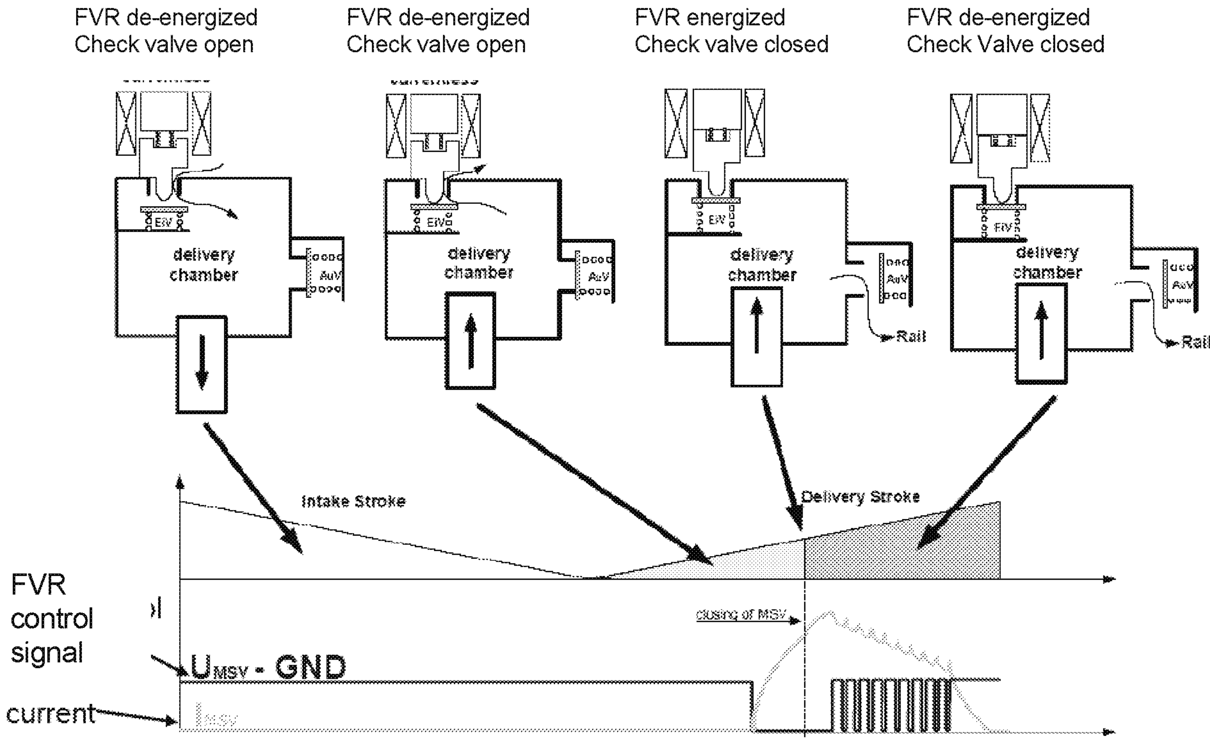
The Fuel Volume Regulator (FVR) is a solenoid valve permanently mounted to the pump assembly. It selects one of two plumbing elements upstream of the pump chamber. The next figure shows the solenoid valve in the un-powered position.)

| Solenoid State | Plumbing Element Selected |
|---|---|
| Un-powered | Flow Through (i.e. Check Valve Disabled) |
| Energized | Check Valve |

The FVR control is done synchronous to the cam position on which the pump is mounted. The synchronous FVR control must take into account that the camshaft phasing is varied during engine operation for purposes of valve control.



High Pressure Pump Plumbing Schematic




Fuel Volume Regulator Control

The FVR solenoid coil may overheat and fail if constant battery voltage is applied.  For that reason, the PCM is equipped with protections to prevent FVR damage due certain wiring faults.

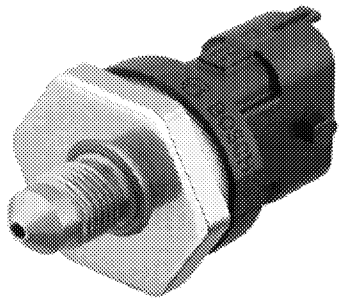
The FVR is a two wire device (high and low side control) with both wires routed to the PCM. This means that either or both wires can generate the DTC(s).

| Fuel Volume Regulator  Circuit Check Operation | |
|---|---|
| DTCs | P0001 Fuel Volume Regulator Control Circuit / Open<br>P0003 Fuel Volume Regulator Control Circuit Low<br>P0004 Fuel Volume Regulator Control Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | not applicable |

## Fuel Rail Pressure Sensor

The fuel rail pressure control system uses the measured fuel rail pressure in a feedback control loop to achieve the desired fuel rail pressure. The fuel injection algorithm uses actual fuel rail pressure in its computation of fuel injector pulse width and fuel injection timing.

The Fuel Rail Pressure sensor is a gauge sensor. Its atmospheric reference hole is in the electrical connector. The fuel rail pressure sensor has a nominal range of 0 to 26 MPa (0 to 260 bar, 0 to 3770 psi). This pressure range is above the maximum intended operating pressure of 15 MPa and above the pressure relief valve setting of 19.4 MPa. The sensor voltage saturates at slightly above 0.2 and slightly below 4.8 volts.



Fuel Rail Pressure Sensor

Fuel rail pressure can develop a vacuum when the vehicle cools after running. Vacuums can be measured by the FPR gauge sensor as voltages near the 0.2 Volt limit.

| **FRP Sensor Transfer Function** | | |
|---|---|---|
| FRP = −471.37 psi + (FRP_voltage / 5.0 volts) * 4713.73 psi | | |
| **Volts** | **Pressure, MPa (gauge)** | **Pressure, psi (gauge)** |
| 4.80 | 27.95 | 4054 |
| 4.50 | 26 | 3771 |
| 3.50 | 19.5 | 2828 |
| 2.50 | 13.0 | 1885 |
| 1.50 | 6.5 | 943 |
| 0.50 | 0 | 0 |
| 0.20 | -1.95 | -283 |

| FRP Open/Short Check Operation: | |
|---|---|
| DTCs | P0192 - Fuel Rail Pressure Sensor A Circuit Low<br>P0193 - Fuel Rail Pressure Sensor A Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical FRP Sensor Check Malfunction Thresholds: |
|---|
| FRP voltage < 0.20 volts or FRP voltage > 4.80 volts |

A fuel pressure sensor that is substantially in error results in a fuel system fault (too rich / too lean). If actual fuel rail pressure exceeds measured pressure, more fuel than that which would be expected is injected and vice versa. This fuel error would show up in the long term and short term fuel trim.

## Fuel Rail Pressure Control

Fuel rail pressure is maintained via:

- Feed-forward knowledge of pump command and injector fuel quantity and
- Feedback knowledge of sensed pressure.

A set point pressure is determined by engine operating conditions. If a pressure increase is desired, the fuel pump effective stroke is increased via FVR valve timing. Pressure decreases are analogous; however, without injection fuel rail pressure cannot be decreased. Acting alone, the pump can only increase pressure.

In theory, the PCM could exactly account for mass entering the rail via the pump and exiting the rail via the injectors, however, since both the pump timing and injector timing are constantly changing and interact, this is very difficult. Thus, the pump control performs fuel pressure control as a continuous process. It calculates average fuel mass over 720° (one engine cycle) and average fuel pressure over 240°. Control is executed at engine firing rate 240°.

For diagnostic purposes, fuel fractional pressure error is computed as a ratio of the pressure error over the desired pressure. This unitless ratio is then compared to thresholds to yield fuel pressure too low (P0087) or fuel pressure too high (P0088).

| Fuel Rail Pressure Control (Normal) Functional Check Operation: | |
|---|---|
| DTCs | P0087 (Fuel Rail Pressure Too Low)<br>P0088 (Fuel Rail Pressure Too High) |
| Monitor execution | continuous |
| Monitor Sequence | P0087 and P0088 must complete before setting P00C6 or P053F |
| Sensors/Actuators OK | FLI, FRP, FVR,, Lift Pump |
| Monitoring Duration | not applicable |

| Typical Fuel Rail Pressure Control (Normal) Functional Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| High Pressure Pump Enabled | Enabled | |
| Fuel level | 15% | |
| Injector Cut Off | No Injector Cut Off | |
| Injection Volume / (720° Pump Volume / Number of Cylinders) | 0.05 | 0.90 |
| Engine Coolant Temperature | 20°F | 250°F |
| CSER Mode | Not in CSER | |

| Typical Fuel Rail Pressure Control (Normal) Functional Check Malfunction Thresholds: |
| --- |
| P0087: (Fuel_Pressure_Desired – Fuel_Pressure_Actual) / Fuel_Pressure_Desired > 0.25 |
| P0088: – (Fuel_Pressure_Desired – Fuel_Pressure_Actual) / Fuel_Pressure_Desired > 0.25 |

## Fuel Rail Pressure Control (Cranking)

The engine is designed to start with a minimum required fuel injection pressure. If that minimum fuel injection pressure is not achived before the first fuel injection, a fault is set.

| Fuel Rail Pressure Control (Cranking) Functional Check Operation: | |
| --- | --- |
| DTCs | P00C6 (Fuel Rail Pressure Too Low – Engine Cranking) |
| Monitor execution | Minimum pressure met instantaneously once during cranking |
| Monitor Sequence | P0087 and P0088 must pass before setting P00C6 or P053F |
| Sensors/Actuators OK | FLI, FRP, FVR,, Lift Pump |
| Monitoring Duration | Minimum met instantaneously once during cranking |

| Typical Fuel Rail Pressure Control (Cranking) Functional Check Entry Conditions: | | |
| --- | --- | --- |
| Entry Condition | Minimum | Maximum |
| Fuel level | 15% | |

| Typical Fuel Rail Pressure Control (Cranking) Functional Check Malfunction Thresholds: |
| --- |
| Fuel_Pressure_Actual >= Fuel_Pressure_Desired |

## Fuel Rail Pressure Control (CSER)

While not used in this first GTDI application, it is possible that during catalyst heating (CSSER) the fuel injection timing may be unique to this mode. In future cases, a two squirt injection may be used. One of those injection squirts would occur during the compression stroke. Compression injection is only allowed within a calibrated fuel pressure "window". The P053F detection monitors the time fraction within that fuel pressure window.

| Fuel Rail Pressure Control (CSER) Functional Check Operation: | |
|---|---|
| DTCs | P053F (Cold Start Fuel Pressure Control Performance) |
| Monitor execution | During CSER |
| Monitor Sequence | P0087 and P0088 must pass before setting P00C6 or P053F |
| Sensors/Actuators OK | FLI, FRP, FVR, Lift Pump |
| Monitoring Duration | Entire CSER period |

| Typical Fuel Rail Pressure Control (CSER) Functional Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Fuel level | 15% | |

| Typical Fuel Rail Pressure Control (CSER) Functional Check Malfunction Thresholds: |
|---|
| Time in Fuel Injection Pressure Window / CSER Duration > 0.70 |
| Fuel Injection Pressure Window defined as follows: |
| Minimum Fuel Pressure to Support Desired Injection Mode <= Fuel Pressure Actual |
| Fuel Pressure Actual <= Maximum Fuel Pressure to Support Desired Injection Mode |

# Electronic Throttle Control

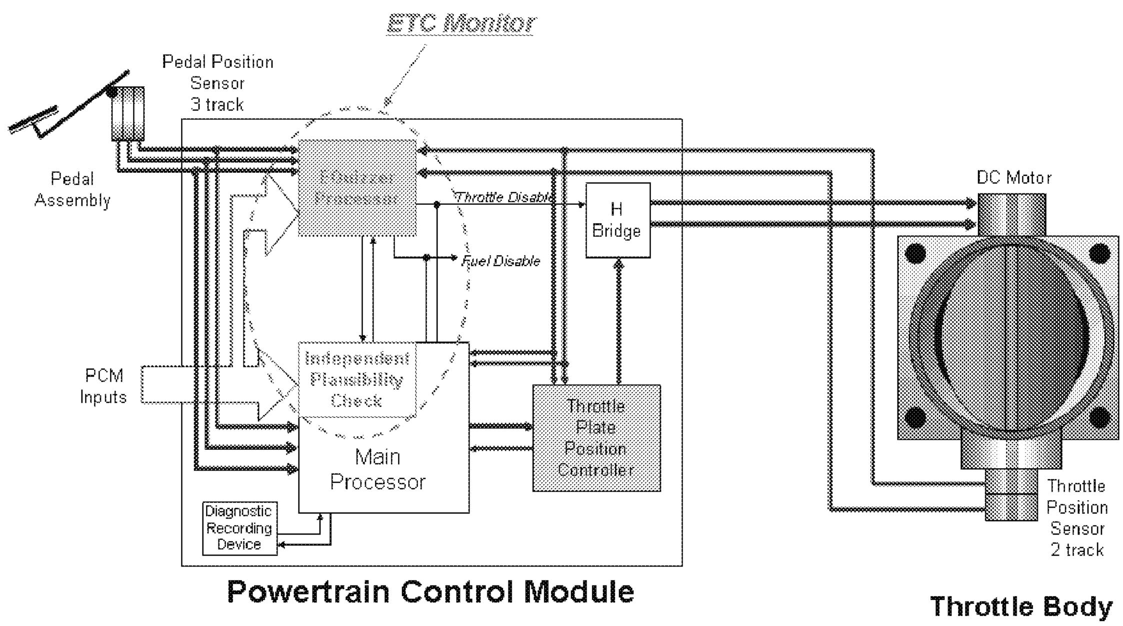
The Electronic Throttle Control (ETC) system uses a strategy that delivers engine or output shaft torque, based on driver demand, utilizing an electronically controlled throttle body. ETC strategy was developed mainly to improve fuel economy. This is possible by decoupling throttle angle (produces engine torque) from pedal position (driver demand). This allows the powertrain control strategy to optimize fuel control and transmission shift schedules while delivering the requested engine or wheel torque.

The Gen2 ETC system was first introduced in 2003MY Ford products. This system evolved into the Gen3 ETC system in 2008MY and the Gen4 ETC system in 2009MY. The Gen3 and Gen4 ETC systems made improvements over the Gen2 system by reducing complexity, improving reliability, and optimizing cost. The primary changes made for the Gen3 / Gen4 ETC systems were the following:

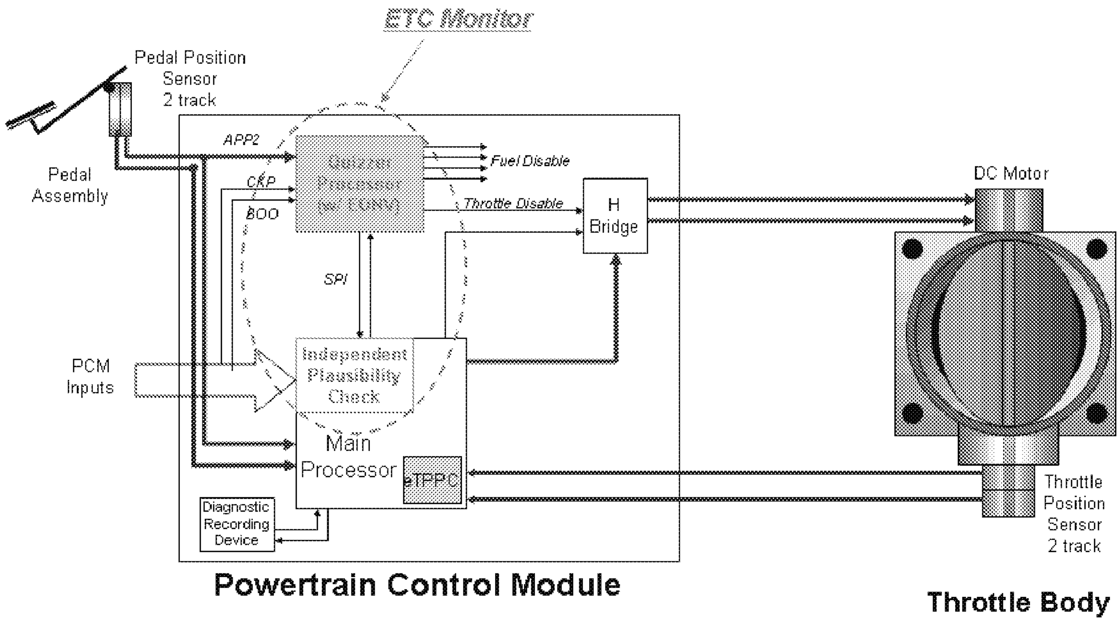
- Replace 3-track sensor Accelerator Pedal with 2-track sensor Accelerator Pedal.
- Introduce single plunger dual output brake switch.
- Integrate the Throttle Plate Position Controller (eTPPC) into the main processor within PCM.
- Reduce Quizzer complexity and integrate with the EONV function.

The Gen3 / Gen4 ETC systems have equivalent hardware systems with only software differences.

## Gen 2 ETC System



# Gen 3 / Gen 4 ETC System




Because safety is a major concern with ETC systems, a complex safety monitor strategy (hardware and software) was developed. The monitor system is distributed across two processors: the main powertrain control processor and a monitoring processor called a Quizzer processor.

The primary monitoring function is performed by the Independent Plausibility Check (IPC) software, which resides on the main processor. It is responsible for determining the driver-demanded torque and comparing it to an estimate of the actual torque delivered. If the generated torque exceeds driver demand by specified amount, the IPC takes appropriate mitigating action.

Since the IPC and main controls share the same processor, they are subject to a number of potential, common-failure modes. Therefore, the Quizzer processor was added to redundantly monitor selected PCM inputs and to act as an intelligent watchdog and monitor the performance of the IPC and the main processor. If it determines that the IPC function is impaired in any way, it takes appropriate Failure Mode and Effects Management (FMEM) actions.

| ETC System Failure Mode and Effects Management: | |
|---|---|
| Effect | Failure Mode |
| No Effect on Drivability | A loss of redundancy or loss of a non-critical input could result in a fault that does not affect drivability. The Wrench light will turn on, but the throttle control and torque control systems will function normally. |
| RPM Guard w/ Pedal Follower | In this mode, torque control is disabled due to the loss of a critical sensor or PCM fault. The throttle is controlled in pedal-follower mode as a function of the pedal position sensor input only. A maximum allowed RPM is determined based on pedal position (RPM Guard.) If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The wrench light and the MIL are turned on in this mode and an ETC component causal code is set. EGR, VCT, and IMRC outputs are set to default values. |
| RPM Guard w/ Default Throttle | In this mode, the throttle plate control is disabled due to the loss of Throttle Position, the Throttle Plate Position Controller, or other major ETC system fault. A default command is sent to the (e)TPPC, or the H-bridge is disabled. Depending on the fault detected, the throttle plate is controlled or springs to the default (limp home) position. A maximum allowed RPM is determined based on pedal position (RPM Guard.) If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The wrench light and the MIL are turned on in this mode and an ETC component causal code is set. EGR, VCT, and IMRC outputs are set to default values. |
| RPM Guard w/ Forced High Idle<br><br>(Gen 2 only) | This mode is caused by the loss of 2 or 3 pedal position sensor inputs due to sensor, wiring, or PCM faults. The system is unable to determine driver demand, and the throttle is controlled to a fixed high idle airflow. There is no response to the driver input. The maximum allowed RPM is a fixed value (RPM Guard.) If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The wrench light and the MIL are turned on in this mode and a P2104 is set. EGR, VCT, and IMRC outputs are set to default values. |
| SLOWE / BOA<br>(Gen3 / Gen4 only) | This mode is caused by the loss of 1 or 2 pedal position sensor inputs due to sensor, wiring, or PCM faults. For a single sensor fault, driver demand is rate limited based on input from the remaining good sensor. For a dual sensor fault, driver demand is ramped to a fixed pedal position (high idle RPM) and there is no response to the driver input. If the brake pedal is applied for either a single or dual sensor fault, the engine returns to a normal idle RPM. The wrench light is turned on in this mode, and an accelerator pedal sensor causal code is set. |
| Shutdown<br>(Gen2 only) | If a significant processor fault is detected, the monitor will force vehicle shutdown by disabling all fuel injectors. The wrench light is turned on in this mode and a P2105 is set.<br>Note: Vehicle shutdown does not increase emissions; therefore the MIL is not required to be illuminated for this fault. |
| | Note: The wrench light illuminates or an ETC message is displayed on the message center immediately. The MIL illuminates after 2 driving cycles. |

## Accelerator and Throttle Position Sensor Inputs

| On-demand KOEO / KOER Sensor Check Operation: | |
|---|---|
| DTCs | P1124 – TP A out of self-test range (non-MIL) [Gen3 / Gen4 only]<br>P1575 – APP out of self-test range (non-MIL) [Gen3 / Gen4 only] |
| Monitor execution | On-demand |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| Accelerator Pedal Position Sensor Check Operation: | |
|---|---|
| DTCs | P2122, P2123 – APP D circuit continuity (wrench light, non-MIL)<br>P2121 – APP D range/performance (wrench light, non-MIL) [Gen2 only]<br>P2127, P2128 – APP E circuit continuity (wrench light, non-MIL)<br>P2126 – APP E range/performance (wrench light, non-MIL) [Gen2 only]<br>P2132, P2133 – APP F circuit continuity (wrench light, non-MIL) [Gen2 only]<br>P2131 – APP F range/performance (wrench light, non-MIL) [Gen2 only]<br>P2138 – APP D/E circuit disagreement (wrench light, non-MIL) [Gen3 / Gen4 only] |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| APP sensor check malfunction thresholds: |
|---|
| Circuit continuity - Voltage < 0.25 volts or voltage > 4.75 volts<br>Range/performance – disagreement between sensors > 1.1 degrees |

| Throttle Position Sensor Check Operation: | |
|---|---|
| DTCs | P0122, P0123 – TP A circuit continuity (MIL, wrench light)<br>P0222, P0223 – TP B circuit continuity (MIL, wrench light)<br>P2135 – TP A / TP B correlation (non-MIL, wrench light)<br>P0121 – TP A range/performance (non-MIL) [Gen2 only]<br>P0221 – TP B range/performance (non-MIL) [Gen2 only] |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| TP sensor check malfunction thresholds: |
|---|
| Circuit continuity - Voltage < 0.25 volts or voltage > 4.75 volts<br>Correlation and range/performance – disagreement between sensors > 7 degrees |

## Electronic Throttle Monitor

| Electronic Throttle Monitor Operation: | |
|---|---|
| DTCs | P2106 – ETC FMEM – forced limited power; sensor fault: MAF, one TP, CKP, TSS, OSS, stuck throttle, throttle actuator circuit fault (MIL, wrench light) [Gen2 only]<br>P2110 – ETC FMEM – forced limited rpm; two TPs failed; TPPC detected fault (MIL, wrench light) [Gen2 only]<br>P2104 – ETC FMEM – forced idle, two or three pedal sensors failed (MIL, wrench light) [Gen2 only]<br>P2105 – ETC FMEM – forced engine shutdown; Quizzer detected fault (non-MIL, wrench light) [Gen2 only]<br>U0300 – ETC software version mismatch, IPC, Quizzer or TPPC (Non-MIL, wrench light for Gen2; MIL, wrench light for Gen3 / Gen4)<br>P0600 – Serial Communication Link (Non-MIL, wrench light for Gen2; MIL, wrench light for Gen3 / Gen4)<br>P060A – Internal control module monitoring processor performance (Non-MIL, wrench light for Gen2; MIL, wrench light for Gen3 / Gen4)<br>P060B – Internal control module A/D processing performance (MIL, wrench light)<br>P060C – Internal control module main processor performance (MIL, wrench light)<br>P060D – Internal control module accelerator pedal performance (non-MIL) [Gen3 / Gen4 only]<br>P061B – Internal control module torque calculation performance (MIL, wrench light)<br>P061C – Internal control module engine rpm performance (MIL, wrench light)<br>P061D – Internal control module engine air mass performance (MIL, wrench light)<br>P061F – Internal control module throttle actuator controller performance (MIL, wrench light for Gen2; non-MIL for Gen3 / Gen4)<br>P062C – Internal control module vehicle speed performance (MIL, wrench light) [Gen2 only]<br>P1674 – Internal control module software corrupted (Non-MIL, wrench light for Gen2; MIL, wrench light for Gen3 / Gen4) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

## Throttle Plate Position Controller (TPPC) Outputs

The purpose of the TPPC is to control the throttle position to the desired throttle angle. The Gen2 ETC system has a separate chip embedded in the PCM. The Gen3 / Gen4 ETC systems have the eTPPC function integrated in the main PCM processor.

For the stand alone TPPC, the desired throttle angle is communicated from the main CPU via a 312.5 Hz duty cycle signal. The TPPC interprets the duty cycle signal as follows:

0% <= DC < 4% - Out of range, limp home default position.

4% <= DC < 6% - Commanded default position, closed.

6% <= DC < 7% - Commanded default position. Used for key-on, engine off.

7% <= DC < 8% - Ice Breaker Mode.

8% <= DC < 10% - Closed against hard-stop. Used to learn zero throttle angle position (hard-stop) after key-up

10% <= DC <=92% - Normal operation, between 0 degrees (hard-stop) and 82%, 10% duty cycle = 0 degrees throttle angle, 92% duty cycle = 82 degrees throttle angle.

92% < DC <= 96% - Wide Open Throttle, 82 to 86 degrees throttle angle.

96% < DC <= 100% - Out of Range, limp home default position

The desired angle is relative to the hard-stop angle. The hard-stop angle is learned during each key-up process before the main CPU requests the throttle plate to be closed against the hard-stop. The output of the (e)TPPC is a voltage request to the H-driver (also in PCM). The H driver is capable of positive or negative voltage to the Electronic Throttle Body Motor.

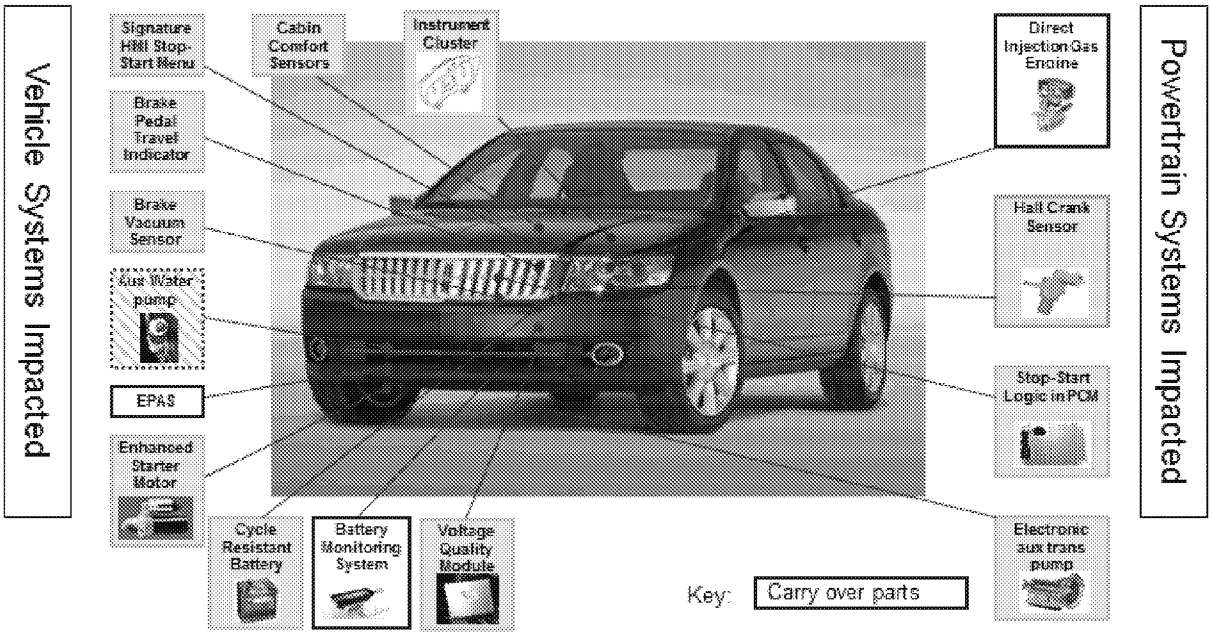
| Throttle Plate Controller and Actuator Operation: | |
|---|---|
| DTCs | P2107 – processor test (MIL, wrench light)<br>P2111 – throttle actuator system stuck open (MIL, wrench light)<br>P2112 – throttle actuator system stuck closed (MIL, wrench light)<br>P2100 – throttle actuator circuit open, short to power, short to ground (non-MIL, wrench light) [Gen2 only]<br>P2101 – throttle actuator range/performance test (MIL, wrench light)<br>P2072 – throttle body ice blockage (non-MIL) [Gen2 only]<br>P115E – throttle actuator airflow trim at max limit (non-MIL) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | < 5 seconds to register a malfunction |

# Stop Start

## Stop Start Overview

The 2013 MY Fusion will incorporate Stop Start. Stop-Start will automatically turn off the engine when the vehicle is stopped, such as at traffic lights, to avoid fuel waste due to unnecessary engine idle. Upon brake pedal release, the engine will automatically restart offering normal vehicle response. The vehicle may not turn off the engine when stopped depending on customer comfort settings or vehicle conditions.

The benefits are improved fuel economy and reduced exhaust emissions. Stop Start affects many components and subsystems in the vehicle as shown in the diagram below.




## Stop Start Diagnostics

Existing diagnostics for the thermostat monitor had to be revised to accommodate stop-start. The ECT model used for the thermostat had to be revised to accommodate engine pull downs.

Diagnostics were added for new/improved hardware:

- Bi-directional crankshaft sensor
- Electric transmission fluid pump
- Auxiliary water pump
- Voltage quality module
- Brake vacuum sensor
- Stop-Start button
- Battery Monitor System
- Brake Switch

## Stop Start Enable Conditions:

Stop Start is enabled during a normal driving cycle based on the entry conditions listed in the table below:

| Input | Stop-Start Inhibit Conditions | Rationale |
|---|---|---|
| ECT | 140 deg F < ECT > 230 deg F | Combustion Stability |
| BARO | BARO <= 20 in Hg (Altitude <= 10,000 ft) | Minimum Air Charge |
| FRP at Idle | Fuel Rail Pressure (FRP) at Idle >= 45 Bar | Restart Combustion Stability |
| FRP w/Engine Off | FRP at engine off >= FRP at Idle with max drop of 5 Bar. If FRP at eng off drops below threshold, request pull-up | Restart Combustion Stability |
| Time Since Key-Start | 10 seconds | Oil Stabilization and Learn Closed Throttle |
| Max Crank Time | Max Crank Time should be min of 5 sec below limit to allow a shutdown | To avoid a possible max crank fault |
| Low Fuel Level | fuel level below 15% | Avoid starts on empty fuel tank |
| Purge complete | Canister Purge Valve no closed before end of pre stop period | Wait for purge to complete before pulling down engine |
| Adaptive Fuel Complete | Adaptive fuel learning not complete | If Adaptive fuel learning is in process, wait for it to complete before pull down |

## Stop Start Disable Conditions:

Stop-Start is inhibited if any of the following DTCs are set. This is intended to ensure that starting is not compromised.

**FVR** (P0001, P0003, P0004), **Low Pres Fuel** (P008A, P008B), **Crank Fuel Press** (P00C6),

**VVT** (P0010, P0011, P0012, P0013, P0014, P0015, P0016, P0017),

**AAT** (P0072, P0073, P0074), **IAT** (P00CE), **High Pres Fuel** (P0087, P0088),

**IAT2** (P0096, P0097, P0098), **MAF** (P0100, P0102, P0103, P1101), **MAF/TP** (P0068),

**MAP** (P0106, P0107, P0108, P0109), **IAT1** (P0111, P0112, P0113, P0114),

**ECT** (P0116, P0117, P0118, P0119), **TP1** (P0122, P0123), **TP2** (P0222, P0223),

**Fuel Monitor** (P0148, P0171, P0172), **LP FP** (P018C, P018D), **FRP** (P0192, P0193),

**Injectors** (P0201, P0202, P0203, P0204), **Misfire** (P0300, P0301, P0302, P0303, P0304),

**Fuel Pump** (P025A, P025B, P0230, P0231, P0232, P0627, P064A),

**CMP A** (P0340, P0341, P0344), **Coils** (P0351, P0352, P0353, P0354),

**CMP B** (P0365, P0366, P0369), **Idle Speed** (P0505, P0506, P0507), **Starter** (P0615, P06E9, P162F),

**ETC** (P2100, P2101, P2107, P2111, P2112), **APP** (P2122, P2123, P2127, P2128, P2135, P2138),

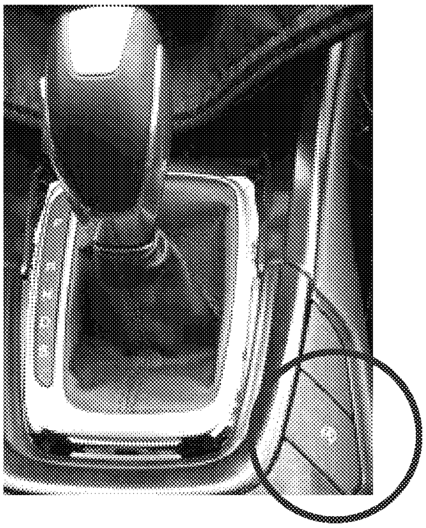
**BARO** (P2227, P2228, P2229, P2230), **PCV** (P2282),

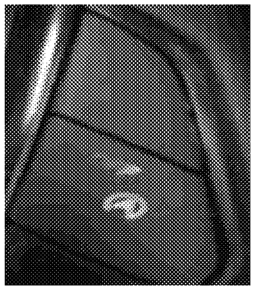
**Coils** (P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310)

## Stop Start Customer Interface

The 2013 MY Fusion will incorporate Stop Start. Start/stop is enabled for every start as the default condition. It cannot be permanently disabled.

Auto Start/stop can be disabled (and re-enabled) by pressing the button on the console, which lights up with the word OFF next to the auto start/stop symbol. This is very similar to how other features, like traction control or back-up warning works.

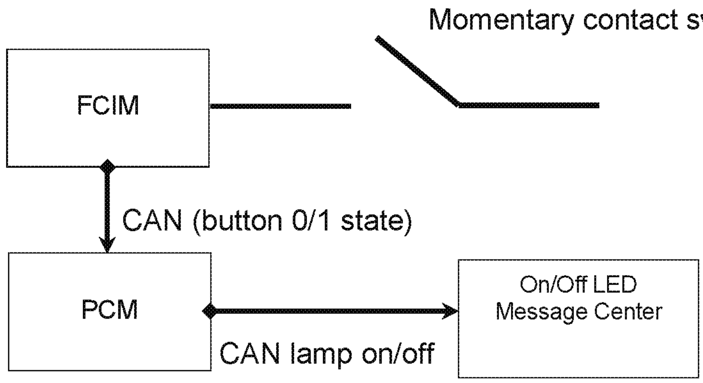




If you have the message center displaying the auto start/stop feature messages, it will tell you when you come to a stop that auto start/stop is disabled by the driver.

### Stop Start Button

The stop-start disable button is a momentary contact switch. It is normally open, CAN signal low. Closed (button being pushed) is CAN signal high. The Front Controls Interface Module reads the switch status and sends it over CAN to the PCM.




The PCM looks for a low to high transition to toggle the status of Stop-start from enabled (default state) to disabled. If there is another low to high transition, stop-start will go from disabled to enabled.

If the PCM stops receiving data from the FCIM, the PCM sets a U0256 - Lost Communication with Front Controls Interface Module "A".

If the FCIM detects that the switch is shorted to ground, it sets a B12CB -11 Start/Stop "Eco-Start" Enable Button Circuit Short To Ground. DTC sets if the button is pushed for 4 continuous seconds (8 samples) but will clear it if the fault is not detected any time after that for 500 msec

If the FCIM detects that the status indicator is shorted to ground, it sets a B12CA-11 - Start/Stop "Eco-Start" Status Indicator Circuit Short To Ground

If the FCIM detects that the status indicator is shorted to battery or open, it sets a B12CA-15 -Start/Stop "Eco-Start" Status Indicator Circuit Short To Battery or Open

If the button is stuck open, there are no low to high transitions. Since the PCM does not recognize a button push, stop-start will not be disabled if requested by the customer. All stop-start HMI will continue indicating that stop-start is enabled (e.g. Tell-Tale and IOD).

If the button is stuck closed, there are no low to high transitions. Since the PCM does not recognize a button push, stop-start will not be disabled if requested by the customer. All stop-start HMI will indicate that stop-start is enabled (e.g. Tell-Tale and IOD).

## Engine Temperature Sensor Inputs

Analog inputs such as Intake Air Temperature (P0112, P0113), Engine Coolant Temperature (P0117, P0118), Cylinder Head Temperature (P1289. P1290), Mass Air Flow (P0102, P0103) and Throttle Position (P0122, P0123, P1120), Fuel Temperature (P0182, P0183), Engine Oil Temperature (P0197, P0198), Fuel Rail Pressure (p0192, P0193) are checked for opens, shorts, or rationality by monitoring the analog -to-digital (A/D) input voltage.

| Engine Coolant Temperature Sensor Check Operation: | |
|---|---|
| DTCs | P0117 (low input), P0118 (high input) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical ECT sensor check malfunction thresholds: |
|---|
| Voltage < 0.244 volts or voltage > 4.96 volts |

The ECT rationality test checks to make sure that ECT is not stuck in a range that causes other OBD to be disabled. If after a long (6 hour) soak, ECT is very high (> 230 $^{o}$F) and is also much higher than IAT at start, it is assumed that ECT is stuck high. If after a long (6 hour) soak, ECT is stuck midrange between 175 $^{o}$F (typical thermostat monitor threshold temperature) and 230 $^{o}$F, it is assumed that ECT is stuck mid range.

| ECT Sensor Rationality Check Operation: | |
|---|---|
| DTCs | P0116 (ECT stuck high or midrange) |
| Monitor execution | Once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | ECT, CHT, IAT |
| Monitoring Duration for stuck high | On first valid sample after key on (engine does not have to start) |
| Monitoring Duration for stuck midrange | 5 seconds to register a malfunction |

| Typical ECT Sensor Rationality check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine-off time (soak time) | 360 min | |
| Difference between ECT and IAT (stuck high only) | | 50 deg |
| Engine Coolant Temperature for stuck high condition | 230 $^{o}$F | |
| Engine Coolant Temperature for stuck midrange condition | 175 $^{o}$F | 230 $^{o}$F |

| Typical ECT Sensor Rationality check malfunction thresholds: |
|---|
| ECT stuck high after first valid sample OR ECT stuck midrange for > 5 seconds |

Currently, vehicles use either an ECT sensor or CHT sensor, not both. The CHT sensor measures cylinder head metal temperature as opposed to engine coolant temperature. At lower temperatures, CHT temperature is equivalent to ECT temperature. At higher temperatures, ECT reaches a maximum temperature (dictated by coolant composition and pressure) whereas CHT continues to indicate cylinder head metal temperature. If there is a loss of coolant or air in the cooling system, the CHT sensor will still provide an accurate measure of cylinder head metal temperature. If a vehicle uses a CHT sensor, the PCM software calculates both CHT and ECT values for use by the PCM control and OBD systems.

| **Cylinder Head Temperature Sensor Check Operation:** | |
|---|---|
| DTCs | P1289 (high input), P1290 (low input), P1299 (fail-safe cooling activated) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| **Typical CHT sensor check malfunction thresholds:** |
|---|
| Voltage < 0.244 volts or voltage > 4.96 volts<br>For P1299, MIL illuminates immediately if CHT > 270 ° Fuel shut-off is activated to reduce engine and coolant temperature |

Beginning in the 2013 MY, an Exhaust Metal Temperature (EMT) sensor has been added to the 2.0L GTDI engine in some vehicles along with an ECT sensor. This EMT sensor is located in the cylinder head near the exhaust port. The signal correlates well to ECT during normal operating conditions with a properly filled and sealed coolant system. However, if the engine coolant system was damaged and coolant was low or lost, the EMT sensor will still sense the actual exhaust metal temperature while the ECT could be sitting in air instead of coolant (reading a much lower temperature). This sensor is used strictly for engine component protection via the PCM's "fail-safe" cooling algorithm with diagnostics for open and short circuit faults (P1289, P1290) along with the "fail-safe" cooling fault (P1299). This EMT sensor is actually a CHT sensor that only uses the high range resistor network, hence it uses the CHT "Hot End" transfer function shown below.

| **Cylinder Head Temperature Sensor Check Operation:** | |
|---|---|
| DTCs | P1289 (high input), P1290 (low input), P1299 (fail-safe cooling activated) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| **Typical CHT sensor check malfunction thresholds:** |
|---|
| Voltage < 0.244 volts or voltage > 4.96 volts<br>For P1299, MIL illuminates immediately if CHT > 270 ° Fuel shut-off is activated to reduce engine and coolant temperature |

| Intake Air Temperature Sensor Check Operation: | |
|---|---|
| DTCs | P0112 (low input), P0113 (high input) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical IAT sensor check malfunction thresholds: |
|---|
| Voltage < 0.244 volts or voltage > 4.96 volts |

| Engine Oil Temperature Sensor Check Operation: | |
|---|---|
| DTCs | P0197 (low input), P0198 (high input) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical EOT sensor check malfunction thresholds: |
|---|
| Voltage < 0.20 volts or voltage > 4.96 volts |

| ECT, IAT, EOT Temperature Sensor Transfer Function | | |
|---|---|---|
| **Volts** | **A/D counts in PCM** | **Temperature, degrees F** |
| 4.89 | 1001 | -40 |
| 4.86 | 994 | -31 |
| 4.81 | 983 | -22 |
| 4.74 | 970 | -13 |
| 4.66 | 954 | -4 |
| 4.56 | 934 | 5 |
| 4.45 | 910 | 14 |
| 4.30 | 880 | 23 |
| 4.14 | 846 | 32 |
| 3.95 | 807 | 41 |
| 3.73 | 764 | 50 |
| 3.50 | 717 | 59 |
| 3.26 | 666 | 68 |
| 3.00 | 614 | 77 |
| 2.74 | 561 | 86 |
| 2.48 | 508 | 95 |
| 2.23 | 456 | 104 |
| 1.99 | 407 | 113 |
| 1.77 | 361 | 122 |
| 1.56 | 319 | 131 |
| 1.37 | 280 | 140 |
| 1.20 | 246 | 149 |
| 1.05 | 215 | 158 |
| 0.92 | 188 | 167 |
| 0.80 | 165 | 176 |
| 0.70 | 144 | 185 |
| 0.61 | 126 | 194 |
| 0.54 | 110 | 203 |
| 0.47 | 96 | 212 |
| 0.41 | 85 | 221 |
| 0.36 | 74 | 230 |
| 0.32 | 65 | 239 |
| 0.28 | 57 | 248 |
| 0.25 | 51 | 257 |
| 0.22 | 45 | 266 |
| 0.19 | 40 | 275 |
| 0.17 | 35 | 284 |
| 0.15 | 31 | 293 |
| 0.14 | 28 | 302 |

The Cylinder Head Temp Sensor uses a switchable input circuit to create two transfer functions for cold and hot range temperatures

| CHT Temperature Sensor Transfer Function, Cold End | | |
|---|---|---|
| **Volts** | **A/D counts in PCM** | **Temperature, degrees F** |
| 4.899 | 1002 | -40 |
| 4.861 | 995 | -31 |
| 4.812 | 985 | -22 |
| 4.75 | 972 | -14 |
| 4.671 | 956 | -4 |
| 4.572 | 936 | 4 |
| 4.452 | 911 | 14 |
| 4.309 | 882 | 22 |
| 4.14 | 847 | 32 |
| 3.95 | 808 | 40 |
| 3.737 | 765 | 48 |
| 3.508 | 717 | 58 |
| 3.26 | 666 | 68 |
| 3.00 | 614 | 77 |
| 2.738 | 560 | 87 |
| 2.478 | 507 | 96 |
| 2.226 | 455 | 105 |
| 1.985 | 406 | 114 |
| 1.759 | 360 | 122 |
| 1.551 | 317 | 132 |
| 1.362 | 279 | 141 |
| 1.193 | 244 | 149 |
| 1.043 | 213 | 159 |
| 0.91 | 186 | 168 |
| 0.794 | 162 | 176 |
| 0.693 | 142 | 186 |
| 0.604 | 124 | 194 |
| 0.528 | 108 | 203 |
| 0.462 | 95 | 204 |

| CHT Temperature Sensor Transfer Function, Hot End | | |
|---|---|---|
| **Volts** | **A/D counts in PCM** | **Temperature, degrees F** |
| 4.235 | 866 | 168 |
| 4.119 | 843 | 168 |
| 3.993 | 817 | 176 |
| 3.858 | 789 | 185 |
| 3.714 | 760 | 194 |
| 3.563 | 729 | 203 |
| 3.408 | 697 | 212 |

| | | |
|---|---|---|
| 3.244 | 664 | 221 |
| 3.076 | 629 | 230 |
| 2.908 | 595 | 239 |
| 2.740 | 561 | 248 |
| 2.575 | 527 | 257 |
| 2.411 | 493 | 266 |
| 2.252 | 461 | 275 |
| 2.099 | 430 | 284 |
| 1.953 | 400 | 294 |
| 1.813 | 371 | 303 |
| 1.680 | 344 | 312 |
| 1.556 | 318 | 320 |
| 1.439 | 294 | 329 |
| 1.329 | 272 | 338 |
| 1.228 | 251 | 347 |
| 1.133 | 232 | 356 |
| 1.046 | 214 | 366 |
| 0.965 | 197 | 375 |
| 0.891 | 182 | 383 |
| 0.822 | 168 | 392 |
| 0.760 | 155 | 401 |
| 0.701 | 144 | 408 |
| 0.648 | 133 | 415 |
| 0.599 | 123 | 422 |
| 0.555 | 113 | 428 |
| 0.513 | 105 | 433 |
| 0.476 | 97 | 438 |
| 0.441 | 90 | 442 |
| 0.409 | 84 | 447 |
| 0.380 | 78 | 450 |
| 0.353 | 72 | 454 |
| 0.328 | 67 | 457 |
| 0.306 | 63 | 460 |
| 0.285 | 58 | 463 |
| 0.265 | 54 | 465 |
| 0.248 | 51 | 468 |
| 0.231 | 47 | 470 |
| 0.216 | 44 | 472 |
| 0.202 | 41 | 474 |
| 0.190 | 39 | 475 |
| 0.178 | 36 | 477 |
| 0.167 | 34 | 478 |
| 0.156 | 32 | 480 |

## IAT Rationality Test

The IAT rationality test determines if the IAT sensor is producing an erroneous temperature indication within the normal range of IAT sensor input.

The IAT sensor rationality test is run only once per power-up. The IAT sensor input is compared to the CHT sensor input (ECT sensor input on some applications) at key-on after a long (6 hour) soak. If the IAT sensor input and the CHT (ECT) sensor input agree within a tolerance (+/- 30 deg F), no malfunction is indicated and the test is complete. If the IAT sensor input and the CHT (ECT) sensor input differ by more than the tolerance, the vehicle must be driven over 35 mph for 5 minutes to confirm the fault. This is intended to address noise factors like sun load that can cause the IAT sensor to indicate a much higher temperature than the CHT (ECT) sensor after a long soak. Driving the vehicle attempts to bring the IAT sensor reading within the test tolerance. If the IAT sensor input remains outside of the tolerance after the vehicle drive conditions have been met, the test indicates a malfunction and the test is complete.

In addition to the start-up rationality check, an IAT "Out of Range" check is also performed. The test continuously, checks to see if IAT is greater than the “IAT Out of Range High threshold”, approximately 150 deg F. In order to prevent setting false DTC during extreme ambient or vehicle soak conditions, the same count up/count down timer used for the IAT startup rationality test is used to validate the fault. If IAT is greater than 150 deg F and vehicle speed is greater than ~ 40 mph for 250 seconds then set a P0111.

Either the IAT startup rationality test or the IAT Out of Range High test can set a P0111 DTC. The logic is designed so that either fault can trigger a “two-in-a-row” P0111 MIL, however, both faults must be OK before the P0111 DTC is cleared.

Block heater detection results in a no-call.

| Intake Air Temperature Sensor Range/Performance Check Operation: | |
|---|---|
| DTCs | P0111 (range/performance) |
| Monitor execution | Once per driving cycle, at start-up |
| Monitor Sequence | None |
| Sensors OK | ECT/CHT, IAT, VSS |
| Monitoring Duration | Immediate or up to 30 minutes to register a malfunction |

| Typical Intake Air Temperature Sensor Range/Performance Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine off (soak) time | 6 hours | |
| Battery Voltage | 11.0 Volts | |
| Time since engine start (if driving req'd) | | 30 min |
| Vehicle speed (if driving req'd) | 40 mph | |
| Time above minimum vehicle speed (if driving req'd) | 5 min | |
| IAT - ECT at start (block heater inferred) | -30 °F | -90 °F |

| Typical IAT sensor check malfunction thresholds: |
|---|
| IAT and ECT/CHT error at start-up > +/-30 deg F |

| Intake Air Temperature Sensor Out of Range High Check Operation: | |
|---|---|
| DTCs | P0111 (Out of Range High) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ECT/CHT, IAT, VSS |
| Monitoring Duration | 250 seconds to register a malfunction |

| Typical Intake Air Temperature Sensor Out of Range high Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine off (soak) time | 6 hours | |
| Battery Voltage | 11.0 Volts | |
| Vehicle speed | 40 mph | |
| Time above minimum vehicle speed (if driving req'd) | 5 min | |

| Typical IAT Sensor Out of Range High check malfunction thresholds: |
|---|
| IAT > 150 deg F |

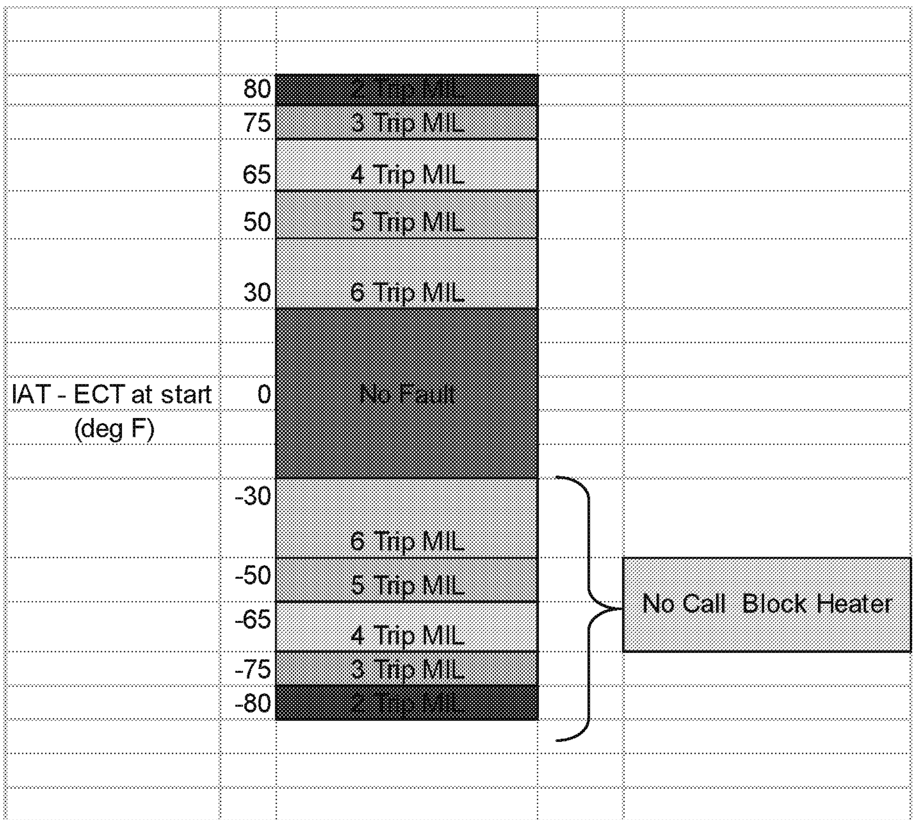
The IAT rationality test employs alternate statistical MIL illumination. This protocol allows up to 6 trips before MIL illumination based on the magnitude of the measured error. The greater the error the fewer number of trips before a DTC will be indicated. In the case of the IAT rationality test the measured error is the difference between the IAT input and the CHT (ECT) input.

The error space is divided into bands. Each band represents a range of error. There are two bands for each of; 5 trips to pending DTC, 4 trips to pending DTC, 3 trips to pending DTC, 2 trips to pending DTC and 1 trip to pending DTC. There are two bands for each because there is one band for positive error and one band for negative error of the same magnitude range.

Counters are maintained that keep track of how many trips a malfunction has occurred within each band. When a sufficient number of trips with a malfunction has been achieved in any band, a P0111 DTC will be set.

If an IAT error, trip to trip, remains just above the IAT-out-of-range error threshold, it will take 6 trips to illuminate the MIL. If the IAT-out-of-range error, trip to trip, is much larger (80 deg F), the MIL will illuminate in the standard 2 trips.

Note that immediately after an KAM clear/battery disconnect, the MIL will be set after two trips regardless of the amount the IAT error exceeds the threshold.



## Fuel Rail Pressure Sensor

| Fuel Rail Pressure Sensor Check Operation: | |
|---|---|
| DTCs | P0192 (low input), P0193 (high input) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 8 seconds to register a malfunction |

| Typical FRP sensor check malfunction thresholds: |
|---|
| Voltage < 0.049 volts or voltage > 4.88 volts |

| Fuel Rail Pressure Sensor Transfer Function | | |
|---|---|---|
| FRP volts = [ Vref * ( 4 * Fuel Pressure / 70) + 0.50 ] / 5.00 | | |
| **Volts** | **A/D counts in PCM** | **Pressure, psi** |
| 4.85 | 993 | 76.125 |
| 4.50 | 922 | 70 |
| 4.00 | 820 | 61.25 |
| 3.50 | 717 | 52.5 |
| 3.00 | 614 | 43.75 |
| 2.50 | 512 | 35 |
| 2.00 | 410 | 26.25 |
| 1.50 | 307 | 17.5 |
| 1.00 | 205 | 8.75 |
| 0.50 | 102 | 0 |
| 0.15 | 31 | -6.125 |

The FRP range/performance test checks to make sure that fuel rail pressure can be properly controlled by the electronic returnless fuel system. The FPS sensor is also checked for in-range failures that can be caused by loss of Vref to the sensor. Note that the FRP is referenced to manifold vacuum (via a hose) while the fuel rail pressure sensor is not referenced to manifold vacuum. It uses gage pressure. As a result, a mechanical gage in the fuel rail will display a different pressure than the FPR PID on a scan tool. The scan tool PID will read higher because of manifold vacuum.

| FRP Range/Performance Check Operation: | |
|---|---|
| DTCs | P0191 (FRP range/performance), P1090 (stuck in range) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | FRP |
| Monitoring Duration | 8 seconds to register a malfunction |

| Typical FRP Sensor Range/Performance check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Demand pressure reasonable | 35 psig | 60 psig |
| Fuel level | 15% | |

| Typical FRP Range/Performance check malfunction thresholds: |
|---|
| Fuel pressure error (demand – actual pressure) > 20 psig |

| Typical FRP Sensor Stuck check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| FRP sensor input | 0 psig | 46 psig |
| FRP input not moving | | 1 psig / sec |

| Typical FRP Stuck check malfunction thresholds: |
|---|
| Fuel pressure error (demand – actual pressure) > 5 psig |

## Mass Air Flow Sensor

The analog MAF sensor uses a hot wire sensing element to measure the amount of air entering the engine. Air passing over the hot wire causes it to cool. This hot wire is maintained at 200°C (392°F) above the ambient temperature as measured by a constant cold wire. The current required to maintain the temperature of the hot wire is proportional to the mass air flow. The MAF sensor then outputs an analog voltage proportional to the intake air mass.

The MAF sensor is located between the air cleaner and the throttle body or inside the air cleaner assembly. Most MAF sensors have integrated bypass technology with an integrated IAT sensor. The hot wire electronic sensing element must be replaced as an assembly. Replacing only the element may change the air flow calibration.

For the 2011 MY, some vehicles will use a digital MAF sensor, which outputs a frequency proportional to the intake air mass.

| MAF Sensor Check Operation: | |
|---|---|
| DTCs | Analog Sensor: P0102 (low input), P0103 (high input)<br>Digital Sensor: P0100 (broken element), P0102 (low input), P0103 (high input) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical MAF sensor check malfunction thresholds: |
|---|
| Analog Sensor: Voltage < 0.244 volts and engine running or voltage > 4.785 volts engine rpm < 4,000 rpm<br>Digital Sensor: With engine running, frequency < 750 Hz or frequency = 0 |

## MAF/TP Rationality Test

The MAF and TP sensors are cross-checked to determine whether the sensor readings are rational and appropriate for the current operating conditions. (P0068)

| MAF/TP Rationality Check Operation: | |
|---|---|
| DTCs | P0068 |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 3 seconds within test entry conditions |

| Typical MAF/TP rationality check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine RPM | 550 rpm | minimum of 5000 rpm |
| Engine Coolant Temp | 150 °F | |

| Typical MAF/TP rationality check malfunction thresholds: |
|---|
| Load > 60% and TP < 2.4 volts or Load < 30% and TP > 2.4 volts |

## Miscellaneous CPU Tests

Loss of Keep Alive Memory (KAM) power (a separate wire feeding the PCM) results is a P1633 DTC and immediate MIL illumination. (Used for those modules that use KAM.)

Vehicles that require tire/axle information and VIN to be programmed into the PCM Vehicle ID block (VID) will store a P1639 if the VID block is not programmed or corrupted.

P0602 - Powertrain Control Module Programming Error indicates that the Vehicle ID block check sum test failed.

P0603 - Powertrain Control Module Keep Alive Memory (KAM) Error indicates the Keep Alive Memory check sum test failed. (Used for those modules that use KAM.)

P0604 - Powertrain Control Module Random Access Memory (RAM) Error indicates the Random Access Memory read/write test failed.

P0605 - Powertrain Control Module Read Only Memory (ROM) Error indicates a Read Only Memory check sum test failed.

P0607 - Powertrain Control Module Performance indicates incorrect CPU instruction set operation, or excessive CPU resets.

P0610 - Powertrain Control Module indicates that one or more of the VID Block fields were configured incorrectly.

P068A - ECM/PCM Power Relay De-energized - Too Early. This fault indicates that NVRAM write did not complete successfully after the ignition key was turned off, prior to PCM shutdown.

P06B8 - Internal Control Module Non-Volatile Random Access Memory (NVRAM) Error indicates Permanent DTC check sum test failed

U0101 - Lost Communication with Transmission Control Module (for vehicles with standalone TCM)

P1934 – Lost Vehicle Speed Signal from ABS Module

## Engine Off Timer Monitor

The engine off timer is either implemented in a hardware circuit in the PCM or is obtained via a CAN message from the Body Control Module.

If the timer is implemented in the PCM, the following applies:

There are two parts to the test. The first part determines that the timer is incrementing during engine off. The test compares ECT prior to shutdown to ECT at key-on. The ECT has cooled down more than 30 deg F and the engine had warmed up to at least 160 deg F prior to shutdown, then an engine off soak has occurred. If the engine off timer indicates a value less than 30 sec, then the engine of timer is not functioning and a P2610 DTC is set.

The second part looks at the accuracy of the engine off timer itself. The timer in the satellite chip is allowed to count up for 5 minutes with the engine running and compared to a different clock in the main microprocessor. If the two timers differ by more than 15 sec (5%), a P2610 DTC is set.

If engine off time is obtained from the BCM, the following applies. There are multiple parts to the test:

The PCM expects to get a CAN message with the engine off time from BCM shortly after start. If the engine off time is not available because of a battery disconnect, the CAN message is set to FFFFh and a U0422 is set (Invalid Data Received from BCM).

If the CAN message with engine off time is not available, a P2610 DTC is set and a U0140 is set (Lost Communication with BCM).

As above, the next part determines that the timer is incrementing during engine off. The test compares ECT prior to shutdown to ECT at key-on. The ECT has cooled down more than 30 deg F and the engine had warmed up to at least 160 deg F prior to shutdown, then an engine off soak has occurred. If the engine off timer indicates a value less than 30 sec, then the engine of timer is not functioning and a P2610 DTC is set.

The last part looks at the accuracy of the engine off timer itself. The timer in the BCM (Global Real Time) is sampled for 5 minutes with the engine running and compared to the clock in the main microprocessor. If the two timers differ by more than 15 sec (5%), a P2610 DTC is set.

| Engine Off Timer Check Operation: | |
|---|---|
| DTCs | P2610 |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Monitoring Duration | Immediately on startup or after 5 minutes |

| Typical Engine Off Timer check malfunction thresholds: |
|---|
| Engine off time < 30 seconds after inferred soak<br>Engine off timer accuracy off by > 15 sec.<br>Engine off time CAN message missing at startup |

| 5 Volt Sensor Reference Voltage A Check: | |
|---|---|
| DTCs | P0642 - Sensor Reference Voltage "A" Circuit Low<br>P0643 - Sensor Reference Voltage "A" Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 sec to register a malfunction |

| Typical 5 Volt Sensor Reference Voltage A check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition "ON" | NA | NA |

| Typical 5 Volt Sensor Reference Voltage A check malfunction thresholds: |
|---|
| P0642<br>Short to ground (signal voltage): < 4.75 V<br>P0643<br>Short to battery plus (signal voltage): > 5.25 V |

| 5 Volt Sensor Reference Voltage A/B/C Check: | |
|---|---|
| DTCs | P06A6 - Sensor Reference Voltage "A" Circuit Range/Performance<br>P06A7 - Sensor Reference Voltage "B" Circuit Range/Performance<br>P06A8 - Sensor Reference Voltage "C" Circuit Range/Performance |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 0.5 sec to register a malfunction |

| Typical 5 Volt Sensor Reference Voltage A/B/C check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition "ON" | NA | NA |

| Typical 5 Volt Sensor Reference Voltage A/B/C check malfunction thresholds: |
|---|
| P0646, P0647, P06A8 (used for Bosch Tricore modules)<br>Reference voltage: < 4.7 V or reference voltage: > 5.2 V |

## Central Vehicle Configuration

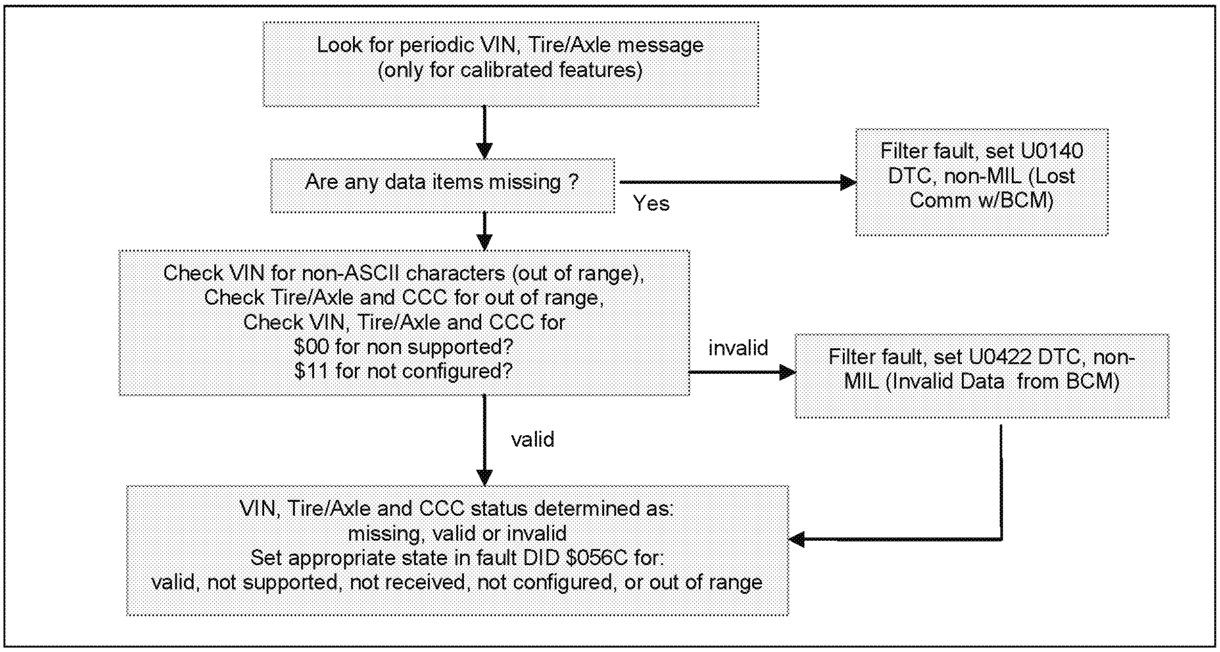
On some applications, the Body Control Module (BCM) transmits VIN, Tire Circumference, Axle Ratio and Cruise Control Configuration (CCC) over the vehicle CAN network to the ECM/PCM as well as to other modules in the vehicle that use this information. Valid data received by the ECM/PCM s stored into NVRAM. This feature is known as Central Vehicle Configuration.

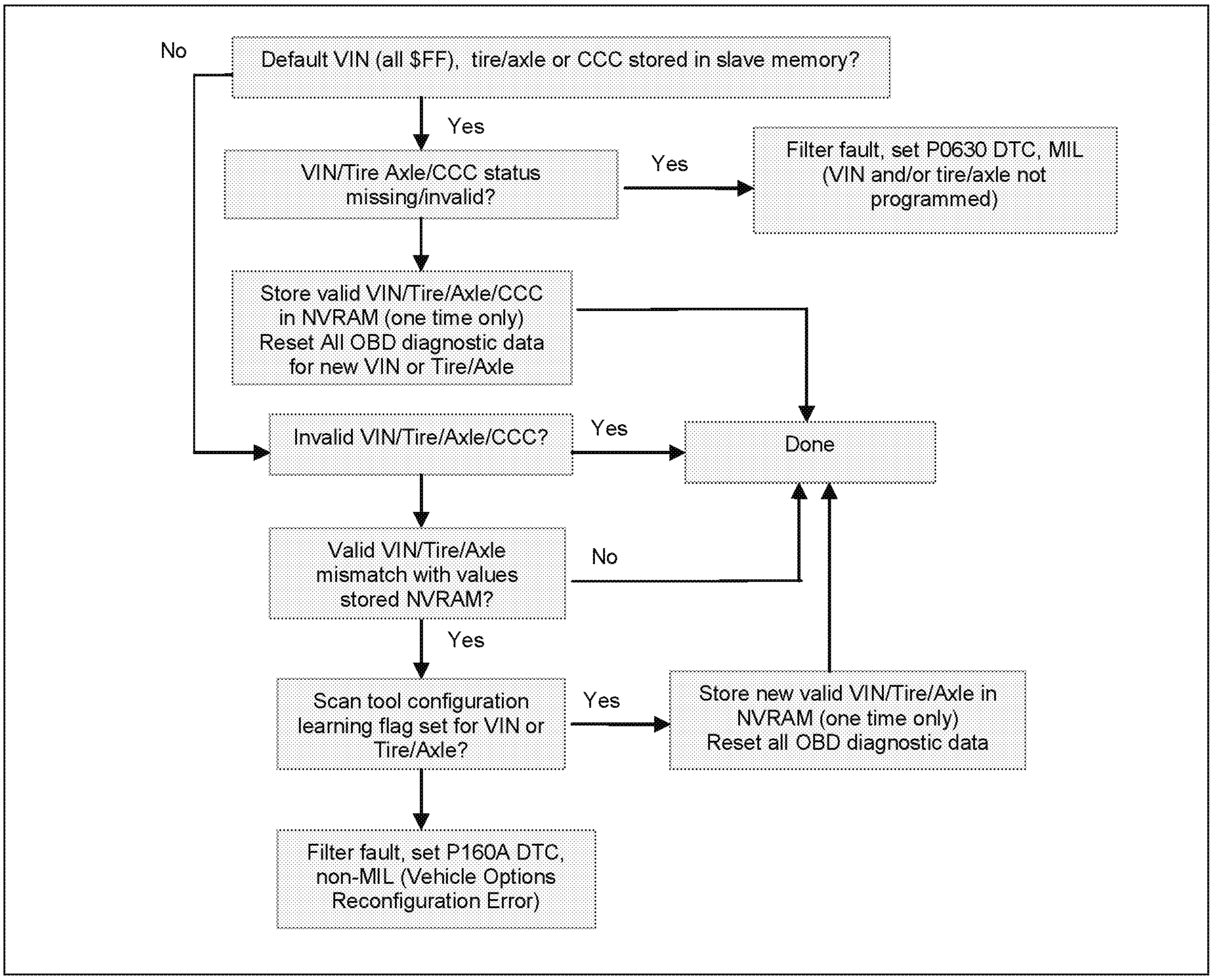
CAN messages with this data are sent every time the vehicle is started. If the CAN messages are not received after start, a U0140 (Lost Communication with BCM) DTC is set. Next, the data is checked to ensure that it is in a valid range. If the VIN, tire, axle or CCC are not in a valid range, a U0422 (Invalid Data received from BCM) DTC is set.

The system is designed to automatically accept valid VIN, tire, axle and CCC data if only the default data ($FF) is stored. If the default VIN, tire and axle are not replaced with valid data at the vehicle assembly plant or after service, a P0630 (VIN and/or tire/axle not programmed) DTC is set and the MIL is illuminated.

Once the PCM has valid VIN, tire, axle and CCC data, and new data is received which does not match the currently stored data, the new data is not stored into NVRAM. If there is a data mismatch, a P160A (Vehicle Options Reconfiguration Error) DTC is set. The new data will not be accepted unless a service tool is used to execute a "learn" command. This allows a service technician to ensure that the vehicle uses the proper configuration data after a BCM or PCM repair. Once a "learn" command is executed, the PCM will accept the next valid VIN, tire, axle and CCC data, store it into NVRAM, and perform and OBD-II code clear which resets all diagnostic data.

The flow charts on the following pages describe the process.




Default VIN (all $FF), tire/axle or CCC stored in slave memory?
No
Yes
VIN/Tire Axle/CCC status missing/invalid?
Yes
Filter fault, set P0630 DTC, MIL (VIN and/or tire/axle not programmed)
Store valid VIN/Tire/Axle/CCC in NVRAM (one time only) Reset All OBD diagnostic data for new VIN or Tire/Axle
Invalid VIN/Tire/Axle/CCC?
Yes
Done
Valid VIN/Tire/Axle mismatch with values stored NVRAM?
No
Yes
Scan tool configuration learning flag set for VIN or Tire/Axle?
Yes
Store new valid VIN/Tire/Axle in NVRAM (one time only) Reset all OBD diagnostic data
Filter fault, set P160A DTC, non-MIL (Vehicle Options Reconfiguration Error)

## Ignition System Tests

New floating point processors no longer use an EDIS chip for ignition signal processing. The crank and cam position signals are now directly processed by the PCM/ECM microprocessor using a special interface called a Time Processing Unit or TPU, or General Purpose Time Array (GPTA), depending on the PCM/ECM. The signals to fire the ignition coil drivers also come from the microprocessor.

Historically, Ford has used a 36-1 tooth wheel for crankshaft position (40-1 on a V-10). Many engines still use a 36-1 wheel; however, some new engines are migrating to a 60-2 tooth wheel for crankshaft position. This was done to commonize ignition hardware and allow Ford to use some industry-standard PCM/ECM designs. 60-2 tooth crank wheels are being used on the 2011/2012 MY 2.0L GDI and GTDI engines, 1.6L GTDI engines and the 3.5L TIVCT GTDI engine.

Over the years, Ford ignition system have migrated away from Distributorless Ignition Systems (DIS) where a given coil pack fires two spark plugs at the same time (one spark plug fires during the compression stroke, the other spark plug fires during the exhaust stroke). All new engine now use Coil On Plug (COP) systems where there is an ignition coil and a coil driver for each spark plug, thus eliminating the need for secondary spark plug wires and improving reliability. Historically, Ford located the ignition coil drivers within the PCM/ECM, however, some new engines are migrating to coils where the driver is located on the coil itself. This eliminates the high current lines going from the PCM to the coils and again, commonizes ignition hardware to allow Ford to use some industry-standard PCM/ECM designs.

The ignition system is checked by monitoring various ignition signals during normal vehicle operation:

> CKP, the signal from the crankshaft 36-1-or 60-2 tooth wheel. The missing tooth is used to locate the cylinder pair associated with cylinder # 1 The microprocessor also generates the Profile Ignition Pickup (PIP) signal, a 50% duty cycle, square wave signal that has a rising edge at 10 deg BTDC for 36-1 systems and 12 deg BTDC for 60-2 systems.
>
> Camshaft Position (CMP), a signal derived from the camshaft to identify the #1 cylinder
>
> Coil primary current (driver in module ignition systems). The NOMI signal indicates that the primary side of the coil has achieved the nominal current required for proper firing of the spark plug. This signal is received as a digital signal from the coil drivers to the microprocessor. The coil drivers determine if the current flow to the ignition coil reaches the required current (typically 5.5 Amps for COP, 3.0 to 4.0 Amps for DIS) within a specified time period (typically > 200 microseconds for both COP and DIS).
>
> Coil driver circuit current and/or voltage (driver on coil ignition systems). The PCM/ECM coil driver IC checks for out of range current and voltage levels at the coil driver output that would indicate an open or short circuit fault. The fault could be located anywhere in the coil driver circuit: PCM/ECM, wiring harness, coil connector, or the driver circuit on the ignition coil. (Note this does not include the primary side windings. Faults in the primary side windings must be detected by the Misfire Monitor for driver on coil ignition systems).

First, several relationships are checked on the CKP signal. The microprocessor looks for the proper number of teeth (35 or 39 or 58) after the missing tooth is recognized; time between teeth too low (< 30 rpm or > 9,000 rpm); or the missing tooth was not where it was expected to be. If an error occurs, the microprocessor shuts off fuel and the ignition coils and attempts to resynchronize itself. It takes on revolution to verify the missing tooth, and another revolution to verify cylinder #1 using the CMP input. Note that if a P0320 or P0322 DTC is set on a vehicle with Electronic Throttle Control, (ETC), the ETC software will also set a P2106.

If the proper ratio of CMP events to PIP events is not being maintained (for example, 1 CMP edge for every 8 PIP edges for an 8-cylinder engine), it indicates a missing or noisy CMP signal (P0340). On applications with Variable Cam Timing (VCT), the CMP wheel has five teeth to provide the VCT system with more accurate camshaft control. The microprocessor checks the CMP signal for an intermittent signal by looking for CMP edges where they would not be expected to be. If an intermittent is detected, the VCT system is disabled and a P0344 (CMP Intermittent Bank 1) or P0349 (CMP intermittent Bank 2) is set.

Finally, for driver in module ignition systems, the relationship between NOMI events and PIP events is evaluated. If there is not an NOMI signal for every PIP edge (commanded spark event), the PCM will look for a pattern of failed NOMI events to determine which ignition coil has failed.

| **CKP Ignition System Check Operation:** | |
|---|---|
| DTCs | P0320 Ignition Engine Speed Input Circuit<br>P0322 Ignition Engine Speed Input Circuit No Signal<br>P0339 Crankshaft Position Sensor "A" Circuit Intermittent<br>P0335 Crankshaft Position Sensor "A" Circuit |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | |
| Monitoring Duration | < 5 seconds |

| **Typical CKP ignition check entry conditions:** | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine RPM for CKP | 500 rpm | |

| **Typical CKP ignition check malfunction thresholds:** |
|---|
| P0320 or P0339:<br>Incorrect number of teeth after the missing tooth is recognized, time between teeth too low (< 30 rpm or > 9,000 rpm), missing tooth was not where it was expected to be.<br>P0322 or P0335:<br>Camshaft indicates > 1 engine revolution while crankshaft signal missing |

| CMP Ignition System Check Operation: | |
|---|---|
| DTCs | P0340 - Intake Cam Position Circuit, Bank 1<br>P0344 – Intake Cam Position Circuit Intermittent, Bank 1<br>P0345 - Intake Cam Position Circuit, Bank 2<br>P0349 – Intake Cam Position Circuit Intermittent Bank 2<br>P0365 - Exhaust Cam Position Circuit, Bank 1<br>P0369 – Intake Cam Position Circuit Intermittent, Bank 1<br>P0390 - Exhaust Cam Position Circuit, Bank 2<br>P0394 – Exhaust Cam Position Circuit Intermittent Bank 2 |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | |
| Monitoring Duration | < 5 seconds |

| Typical CMP ignition check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine RPM for CMP | 200 rpm | |

| Typical CMP ignition check malfunction thresholds: |
|---|
| Ratio of PIP events to CMP events: 4:1, 6:1, 8:1 or 10:1 based on engine cyl.<br>Intermittent CMP signal – CMP signal in unexpected location |

| Coil Primary Ignition System Check Operation: | |
|---|---|
| DTCs | P0351 – P0360 (Coil primary)<br>P2300, P2303, P2306, P2309, P2312, P2315, P2318, P2321, P2324, P2327 (Coil driver short circuit low)<br>P2301, P2304, P2307, P2310, P2313, P2316, P2319, P2322, P2325, P2328 (Coil driver short circuit high)<br>P06D1 (Internal control module ignition coil control module performance) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1 seconds |

| Typical Coil primary ignition check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine RPM for coil primary | 200 rpm | Minimum of 3200 rpm |
| Positive engine torque | Positive torque | |
| Battery Voltage | 11 volts | 16 volts |

| Typical Coil primary ignition check malfunction thresholds: |
|---|
| P035x (driver in module Ignition systems):<br>Ratio of PIP events to IDM or NOMI events 1:1<br>P035x, P23xx (driver on coil Ignition systems):<br>Coil driver circuit current and/or voltage out of range of open and short circuit limits.<br>P06D1 (driver on coil Ignition systems):<br>Missing communication from coil driver IC. |

If an ignition coil primary circuit failure is detected for a single cylinder or coil pair, the fuel injector to that cylinder or cylinder pair will be shut off for 30 seconds to prevent catalyst damage. Up to two cylinders may be disabled at the same time on 6 and 8 cylinder engines and one cylinder is disabled on 4 cylinder engines. After 30 seconds, the injector is re-enabled. If an ignition coil primary circuit failure is again detected, (about 0.10 seconds), the fuel injector will be shut off again and the process will repeat until the fault is no longer present. Note that engine misfire can trigger the same type of fuel injector disablement.

## Knock Sensor

Due to the design of the knock sensor input circuitry, a short to battery, short to ground, or open circuit all result is a low knock signal voltage output. This output voltage is compared to a noise signal threshold (function of engine rpm and load) to determine knock sensor circuit high, circuit low or performance faults.

Some PCM/ECM modules use a driver circuit that will periodically and actively test the knock sensor lines for short circuit faults. In these modules, supplemental codes can be set for the short circuit condition.

Some PCM/ECM modules use a standalone Knock IC. In these modules, the knock signal processing chip SPI bus is checked for proper communication between the main processor and the chip used as the interface the knock sensor.

| Knock Sensor Check Operatio | |
|---|---|
| DTCs | P0325 – Knock Sensor 1 Circuit<br>P0330 – Knock Sensor 2 Circuit<br>P0327 – Knock Sensor 1 Circuit Low<br>P0328 – Knock Sensor 1 Circuit High<br>P0332 – Knock Sensor 2 Circuit Low<br>P0333 – Knock Sensor 2 Circuit High<br>P06B6 – Lost Comm with Knock IC Chip |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Sensors OK | Not in failsafe cooling mode |
| Monitoring Duration | 2.5 seconds |

| Typical Knock Sensor check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Time since engine start (function of ECT) | 60 to 20 sec | |
| Engine Coolant Temperature | 140 °F | |
| Engine load | 35% | |
| Engine speed | 1500 rpm | 6000 rpm |

| Typical Knock Sensor functional check malfunction thresholds: |
|---|
| P0325 & P0330 Knock signal too low (function of engine speed): < 30 to 150 A/D counts (out of 255) |
| P0327, P0332 (used only for PCM/ECM with corresponding diagnostic circuit) |
| Voltage level from active knock sensor circuit probe below limit |
| P0328, P0333 (used only for PCM/ECM with corresponding diagnostic circuit) |
| Voltage level from active knock sensor circuit probe above limit) |
| P06B6 (used only for PCM/ECM with standalone Knock IC) |
| Cylinder events with missing communication from Knock IC > 200 |

## Engine Outputs

The Idle Air Control (IAC) solenoid is checked electrically for open and shorts (P0511) and is functionally checked by monitoring the closed loop idle speed correction required to maintain the desired idle rpm. If the proper idle rpm cannot be maintained and the system has a high rpm (+200) or low rpm error (-100) greater than the malfunction threshold, an IAC malfunction is indicated. (P0507, P0506)

| IAC Check Operation: | |
|---|---|
| DTCs | P0511 (opens/shorts)<br>P0507 (functional - overspeed)<br>P0506 (functional - underspeed) |
| Monitor execution | once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 15 seconds |

| Typical IAC functional check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Coolant Temp | 150 $^{o}$F | |
| Time since engine start-up | 30 seconds | |
| Closed loop fuel | Yes | |
| Throttle Position (at idle, closed throttle, no dashpot) | Closed | Closed |

| Typical IAC functional check malfunction thresholds: |
|---|
| For underspeed error: Actual rpm 100 rpm below target, closed-loop IAC correction > 1 lb/min<br>For overspeed error: Actual rpm 200 rpm above target, closed-loop IAC correction < .2 lb/min |

The PCM monitors the "smart" driver fault status bit that indicates either an open circuit, short to power or short to ground.

| Injector Check Operation: | |
|---|---|
| DTCs | P0201 through P0210 (opens/shorts) |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Monitoring Duration | 5 seconds |

| Typical injector circuit check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 11.0 volts | |

## Electronic Returnless Fuel System

Electronic Returnless Fuel Systems (ERFS) utilize a Fuel Pump Driver Module (FPDM) to control fuel pressure. The PCM uses a Fuel Rail Pressure Sensor (FRP) for feedback. The PCM outputs a duty cycle to the FPDM to maintain the desired fuel rail pressure. During normal operation, the PCM will output a FP duty cycle from 5% to 51%. The FPDM will run the fuel pump at twice this duty cycle, e.g. if the PCM outputs a 42% duty cycle, the FPDM will run the fuel pump at 84%. If the PCM outputs a 75% duty cycle, the FPDM will turn off the fuel pump.

The FPDM returns a duty cycled diagnostic signal back to the PCM on the Fuel Pump Monitor (FPM) circuit to indicate if there are any faults in the FPDM.

If the FPDM does not out any diagnostic signal, (0 or 100% duty cycle), the PCM sets a P1233 DTC. This DTC is set if the FPDM loses power. This can also occur if the Inertia Fuel Switch is tripped.

If the FPDM outputs a 25% duty cycle, it means that the fuel pump control duty cycle is out of range. This may occurs if the FPDM does not receive a valid control duty cycle signal from the PCM. The FPDM will default to 100% duty cycle on the fuel pump control output. The PCM sets a P1235 DTC.

If the FPDM outputs a 75% duty cycle, it means that the FPDM has detected an open or short on the fuel pump control circuit. The PCM sets a P1237 DTC.

If the FPDM outputs a 50% duty cycle, the FPDM is functioning normally.

| Fuel Pump Driver Module Check Operation: | |
|---|---|
| DTCs | P1233 – FPDM disabled of offline<br>P1235 – Fuel pump control out of range<br>P1237 – Fuel pump secondary circuit |
| Monitor execution | Continuous, voltage > 11.0 volts |
| Monitor Sequence | None |
| Monitoring Duration | 3 seconds |

## Mechanical Returnless Fuel System (MRFS) — Single Speed

An output signal from the PCM is used to control the electric fuel pump. The PCM grounds the FP circuit, which is connected to the coil of the fuel pump relay. This energizes the coil and closes the contacts of the relay, sending B+ through the FP PWR circuit to the electric fuel pump. When the ignition is turned on, the electric fuel pump runs for about 1 second and is turned off by the PCM if engine rotation is not detected.

The FPM circuit is spliced into the fuel pump power (FP PWR) circuit and is used by the PCM for diagnostic purposes. With the fuel pump on and the FPM circuit high, the PCM can verify the FP PWR circuit from the fuel pump relay to the FPM splice is complete. It can also verify the fuel pump relay contacts are closed and there is a B+ supply to the fuel pump relay.

## Mechanical Returnless Fuel System (MRFS) — Dual Speed

The FP signal is a duty cycle command sent from the PCM to the fuel pump control module. The fuel pump control module uses the FP command to operate the fuel pump at the speed requested by the PCM or to turn the fuel pump off. A valid duty cycle to command the fuel pump on, is in the range of 15-47%. The fuel pump control module doubles the received duty cycle and provides this voltage to the fuel pump as a percent of the battery voltage. When the ignition is turned on, the fuel pump runs for about 1 second and is requested off by the PCM if engine rotation is not detected.

**FUEL PUMP DUTY CYCLE OUTPUT FROM PCM**

| FP Duty Cycle Command | PCM Status | Fuel Pump Control Module Actions |
|---|---|---|
| 0-15% | Invalid off duty cycle | The fuel pump control module sends a 20% duty cycle signal on the fuel pump monitor (FPM) circuit. The fuel pump is off. |
| 37% | Normal low speed operation. | The fuel pump control module operates the fuel pump at the speed requested. The fuel pump control module sends a 60% duty cycle signal on FPM circuit. |
| 47% | Normal high speed operation. | The fuel pump control module operates the fuel pump at the speed requested. The fuel pump control module sends a 60% duty cycle signal on FPM circuit. |
| 51-67% | Invalid on duty cycle. | The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is off. |
| 67-83% | Valid off duty cycle | The fuel pump control module sends a 60% duty cycle signal on FPM circuit. The fuel pump is off. |
| 83-100% | Invalid on duty cycle. | The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is off. |

The fuel pump control module communicates diagnostic information to the PCM through the FPM circuit. This information is sent by the fuel pump control module as a duty cycle signal. The 4 duty cycle signals that may be sent are listed in the following table.

**FUEL PUMP CONTROL MODULE DUTY CYCLE SIGNALS**

| Duty Cycle | Comments |
|---|---|
| 20% | This duty cycle indicates the fuel pump control module is receiving an invalid duty cycle from the PCM. |
| 40% | For vehicles with event notification signal, this duty cycle indicates the fuel pump control module is receiving an invalid event notification signal from the RCM. For vehicles without event notification signal, this duty cycle indicates the fuel pump control module is functioning normally. |
| 60% | For vehicles with event notification signal, this duty cycle indicates the fuel pump control module is functioning normally. |
| 80% | This duty cycle indicates the fuel pump control module is detecting a concern with the secondary circuits. |

| MRFS Check Operation: | |
| --- | --- |
| DTCs | P025A – Fuel Pump Control Circuit (opens/shorts)<br>P025B – Invalid Fuel Pump Control Data (20% duty cycle from FPM)<br>P0627 – Fuel Pump Secondary Circuit (80% duty cycle from PFM)<br>U2010B – Fuel Pump Disabled Circuit (40% duty cycle from FPM)<br>U0109 – Loss of Communication with Fuel Pump Module |
| Monitor execution | once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 2 seconds |

| TypicalMRFS check entry conditions: | | |
| --- | --- | --- |
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 11 volts | |

| Typical MRFS check malfunction thresholds: |
| --- |
| P025A<br>FP output driver indicates fault<br>P025B, P0627, U210B<br>Fuel Pump Monitor duty cycle feedback of 20, 40 or 80%<br>U0191<br>No Fuel Pump Monitor duty cycle feedback |

There are several different styles of hardware used to control airflow within the engine air intake system. In general, the devices are defined based on whether they control in-cylinder motion (charge motion) or manifold dynamics (tuning).

Systems designed to control charge motion are defined to be Intake Manifold Runner Controls. IMRC systems generally have to modify spark when the systems are active because altering the charge motion affects the burn rate within the cylinder.

Systems designed to control intake manifold dynamics or tuning are defined to be Intake Manifold Tuning Valves. IMTV systems generally do not require any changes to spark or air/fuel ratio because these systems only alter the amount of airflow entering the engine.

## Intake Manifold Runner Control Systems

The Intake Manifold Runner Control (IMRC) consists of a remote mounted, electrically motorized actuator with an attaching cable for each housing on each bank. Some applications will use one cable for both banks. The cable or linkage attaches to the housing butterfly plate levers. (The Focus IMRC uses a motorized actuator mounted directly to a single housing without the use of a cable.)

The IMRC housing is an aluminum casting with two intake air passages for each cylinder. One passage is always open and the other is opened and closed with a butterfly valve plate. The housing uses a return spring to hold the butterfly valve plates closed. The motorized actuator houses an internal switch or switches, depending on the application, to provide feedback to the PCM indicating cable and butterfly valve plate position.

Below approximately 3000 rpm, the motorized actuator will not be energized. This will allow the cable to fully extend and the butterfly valve plates to remain closed. Above approximately 3000 rpm, the motorized actuator will be energized. The attaching cable will pull the butterfly valve plates into the open position. (Some vehicles will activate the IMRC near 1500 rpm.)

The Intake Manifold Swirl Control used on the 2.3L Ranger consists of a manifold mounted vacuum actuator and a PCM controlled electric solenoid. The linkage from the actuator attaches to the manifold butterfly plate lever. The IMSC actuator and manifold are composite/plastic with a single intake air passage for each cylinder. The passage has a butterfly valve plate that blocks 60% of the opening when actuated, leaving the top of the passage open to generate turbulence. The housing uses a return spring to hold the butterfly valve plates open. The vacuum actuator houses an internal monitor circuit to provide feedback to the PCM indicating butterfly valve plate position.

Below approximately 3000 rpm, the vacuum solenoid will be energized. This will allow manifold vacuum to be applied and the butterfly valve plates to remain closed. Above approximately 3000 rpm, the vacuum solenoid will be de-energized. This will allow vacuum to vent from the actuator and the butterfly valve plates to open.

| IMRC System Check Operation: | |
|---|---|
| DTCs | P2014 - IMRC input switch electrical check, Bank 1<br>P2008 - IMRC output electrical check<br>P2004 - IMRC stuck open, electric operated<br>P2004 – IMRC stuck open, vacuum operated, Bank 1<br>P2005 – IMRC stuck open, vacuum operated, Bank 2<br>P2006 – IMRC stuck closed, electric operated |
| Monitor execution | Continuous, after ECT > 40 deg F |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 5 seconds |

| Typical IMRC functional check malfunction thresholds |
| --- |
| IMRC plates do not match commanded position (functional) |
| IMRC switches open/shorted (electrical) |

## Intake Manifold Tuning Valve Systems

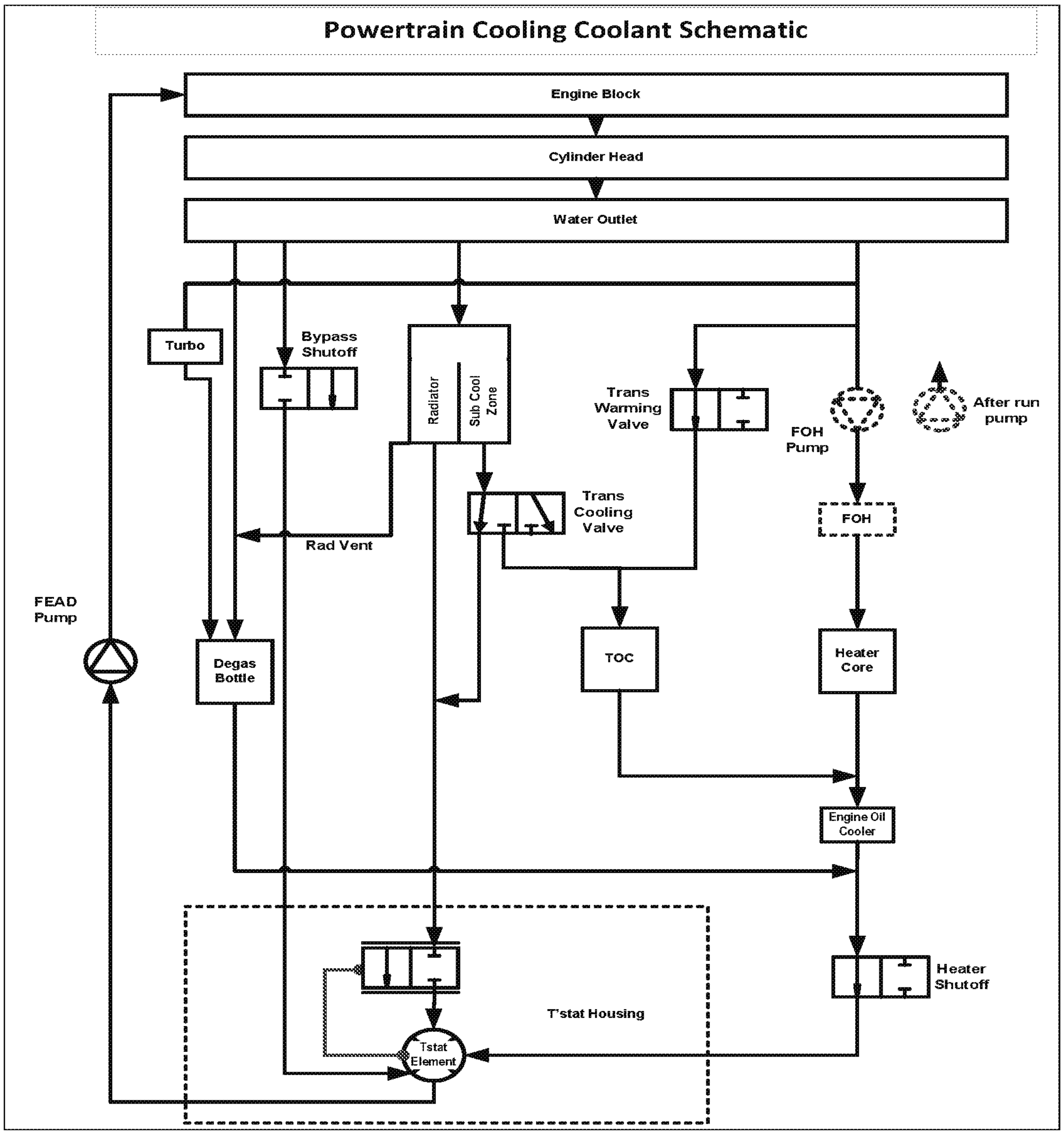
The intake manifold tuning valve (IMTV) is a motorized actuated unit mounted directly to the intake manifold. The IMTV actuator controls a shutter device attached to the actuator shaft. There is no monitor input to the PCM with this system to indicate shutter position.

The motorized IMTV unit will not be energized below approximately 2600 rpm or higher on some vehicles. The shutter will be in the closed position not allowing airflow blend to occur in the intake manifold. Above approximately 2600 rpm or higher, the motorized unit will be energized. The motorized unit will be commanded on by the PCM initially at a 100 percent duty cycle to move the shutter to the open position and then falling to approximately 50 percent to continue to hold the shutter open.

| IMTV Check Operation: | |
| --- | --- |
| DTCs | P1549 or P0660 - IMTV output electrical check (does not illuminate MIL) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 5 seconds |

## Engine Cooling System Outputs

The engine cooling system may contain multiple control valves for improving fluid warm-up rates of both the engine and transmission. These valves are PCM controlled and primarily used for thermal control of engine metal and transmission fluid temperatures by diverting engine coolant to the appropriate component. These digital outputs include an engine coolant bypass valve (CBV), a heater core shut-off valve (HCSO), an active transmission heating valve (ATWU-H), and an active transmission cooling valve (ATWU-C).




The Coolant Bypass Valve is normally closed (de-energized) forcing all of the engine coolant through the radiator to provide maximum "cooling" of the engine and components when the thermostat is open. When opened, a portion of the engine coolant bypasses the radiator providing for coolant pressure and flow control. The Heater Core Shut Off valve has a single purpose which is to limit coolant flow for fast engine warm-up. The ATWU-C valve will transfer engine coolant from the sub-radiator to the Transmission Oil Cooler (TOC) when energized, resulting in a heat transfer from the transmission into the engine coolant (over-temperature control of the transmission). The ATWU-H valve is used to provide hot engine coolant to the TOC to improve transmission fluid temperature control.

The Coolant Bypass Valve output circuit is checked for opens and shorts (P26B7).

| **Coolant Bypass Valve Solenoid Check Operation:** | |
|---|---|
| DTCs | P26B7 – Coolant Bypass Valve Solenoid Circuit |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds |

| **Typical Coolant Bypass Valve Solenoid check malfunction thresholds:** |
|---|
| P26B7 (Coolant Bypass Valve Solenoid Circuit): open/shorted |

The Heater Core Shut-Off Valve output circuit is checked for opens and shorts (P26BD).

| **Heater Core Shut-Off Valve Solenoid Check Operation:** | |
|---|---|
| DTCs | P26BD – Heater Core Shut-Off Valve Solenoid Circuit |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds |

| **Typical Heater Core Shut-Off Valve Solenoid check malfunction thresholds:** |
|---|
| P26BD (Heater Core Shut-Off Valve Solenoid Circuit): open/shorted |

The Active Transmission Heating Valve output circuit is checked for opens and shorts (P2681).

| Active Transmission Heating Valve Solenoid Check Operation: | |
|---|---|
| DTCs | P2681 – Active Transmission Heating Valve Solenoid Circuit |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds |

| Typical Active Transmission Heating Valve Solenoid check malfunction thresholds: |
|---|
| P26B7 (Active Transmission Heating Valve Solenoid Circuit): open/shorted |

The Active Transmission Cooling Valve output circuit is checked for opens and shorts (P26AC).

| Active Transmission Cooling Valve Solenoid Check Operation: | |
|---|---|
| DTCs | P26AC – Active Transmission Cooling Valve Solenoid Circuit |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds |

| Typical Active Transmission Cooling Valve Solenoid check malfunction thresholds: |
|---|
| P26AC (Active Transmission Cooling Valve Solenoid Circuit): open/shorted |

Auxiliary Coolant System Pumps

Some engines will include an auxiliary coolant system pump that is PCM controlled. This is a second cooling pump in the main cooling loop. It is a low power electrically controlled pump which is used to provide engine coolant flow under conditions when the engine is not running and the main mechanical cooling pump is inactive. These auxiliary pumps can be used for two primary purposes: 1) to provide coolant flow through the cabin heat exchanger (heater core) which generates heat for the vehicle cabin (stop/start equipped vehicles), and 2) to provide coolant flow to engine components for the purposes of component protection after the engine is shut-off. On turbo equipped vehicles, engine coolant is used to cool the turbo system bearings resulting in a thermal transfer of heat into the coolant. After-run coolant flow may be required to prevent localized coolant boiling that can damage some cooling system components (particularly the degas bottle).

The auxiliary cooling pump diagnostics include circuit checks for Open (P2600), short-to-power (P2603), short-to-ground (P2602), and a functional performance check (P2601).

| **Auxiliary Cooling System Pump Check Operation:** | |
|---|---|
| DTCs | P2600 – Coolant Pump "A" Control Circuit/Open<br>P2601 – Coolant Pump "A" Control Performance/Stuck Off<br>P2602 – Coolant Pump "A" Control Circuit Low<br>P2603 – Coolant Pump "A" Control Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds |

| **Typical auxiliary cooling system pump circuit check entry conditions:** | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 11.0 volts | |

## Comprehensive Component Monitor - Transmission

### General

The MIL is illuminated for all emissions related electrical component malfunctions. For malfunctions attributable to a mechanical component (such as a clutch, gear, band, valve, etc.), some transmissions are capable of not commanding the mechanically failed component and providing the remaining maximum functionality (functionality is reassessed on each power up)- in such case a non-MIL Diagnostic Trouble Code (DTC) will be stored and, if so equipped, a Transmission Control Indicator Light (TCIL) will flash.

### Transmission Inputs

| Transmission Range Sensor Check Operation: | |
|---|---|
| DTCs | P0705 invalid pattern for digital TRS<br>P0706 Out of range signal frequency for PWM TRS<br>P0707 Signal out of range low for PWM TRS<br>P0708 Open circuit for digital TRS or signal out of range high for PWM TRS |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | Up to 30 seconds for pattern recognition, 5 seconds for analog faults |

| Typical TRS check entry conditions: | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| Gear selector position | each position for up to 30 seconds | 480 seconds |

| Typical TRS malfunction thresholds: |
|---|
| Digital TRS: Invalid pattern from 3 or 5 digital inputs and/or 1 analog circuit open for 5 seconds<br>4-bit digital TRS: Invalid pattern for 200 ms<br>Analog TRS: Voltage > 4.8 volts or < 0.2 volts for 5 seconds<br>Dual analog TRS: Voltage > 4.84 volts or < 0.127 volts for 200 ms or<br>Sum of both inputs is outside the range of 5.0 volts +/- 0.29 volts for 200 ms<br>PWM TRS: Frequency > 175 Hz or < 100 Hz,<br>Duty Cycle > 90% or < 10% |

Most vehicle applications no longer have a standalone vehicle speed sensor input. The PCM sometimes obtains vehicle speed information from another module on the vehicle, i.e. ABS module. In most cases, however, vehicle speed is calculated in the PCM by using the transmission output shaft speed sensor signal and applying a conversion factor for axle ratio and tire programmed into the Vehicle ID block. A Vehicle Speed Output pin on the PCM provides the rest of the vehicle with the standard 8,000 pulses/mile signal.

Note: If the Vehicle ID block has not been programmed or has been programmed with an out-of-range (uncertified) tire/axle ratio, a P1639 DTC will be stored and the MIL will be illuminated immediately.

| **Vehicle Speed Sensor Functional Check Operation:** | |
|---|---|
| DTCs | P0500 – VSS circuit |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 30 seconds |

| **Typical VSS functional check entry conditions:** | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| Gear selector position | drive | |
| Engine rpm (above converter stall speed) OR | 3000 rpm | |
| Turbine shaft rpm (if available) OR | 1500 rpm | |
| Output shaft rpm | 650 rpm | |
| Vehicle speed (if available) | 15 mph | |
| Manual Transmission Entry Conditions | | |
| Engine load | 50 % | |
| Engine rpm | 2400 rpm | |

| **Typical VSS functional check malfunction thresholds:** |
|---|
| Vehicle is inferred to be moving with positive driving torque and VSS is < 1 - 5 mph for 5 seconds |

| Output Shaft Speed Sensor Functional Check Operation: | |
|---|---|
| DTCs | P0720 – OSS circuit<br>P0721 – OSS range/performance -F-21, 6HP26<br>P0722 – OSS no signal<br>P0723 – OSS intermittent/erratic – 6HP26 |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | TSS, Wheel Speed |
| Monitoring Duration | 30 seconds |

| Typical OSS functional check entry conditions: | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| Gear selector position | drive | |
| Engine rpm (above converter stall speed) OR | 3000 rpm | |
| Primary Pulley Speed (CFT30) OR | 400 rpm | |
| Turbine shaft rpm (if available) OR | 1500 rpm | |
| Output shaft rpm | 300 - 650 rpm | |
| Vehicle speed (if available) | 12.5 - 15 mph | |

| Typical OSS functional check malfunction thresholds: |
|---|
| Circuit/no signal - vehicle is inferred to be moving with positive driving torque and OSS < 100 to 200 rpm for 5 to 30 seconds<br>6HP26 Circuit/no signal: open or short circuit for > 0.6 seconds<br>6HP Range/Performance: > 200 rpm difference between OSS and wheel speed and > 250 rpm difference between OSS and input shaft speed<br>F21 Range/Performance: TSS, ABS wheel speed and engine rpm correlate properly, but OSS error is greater than 15% for 10 seconds<br>CFT30 Range/Performance: ABS wheel speed indicates a 6.24 mph difference with OSS calculated wheel speed<br>6HP26 Intermittent/Erratic: > -1000 rpm instantaneous change with locked torque converter clutch<br>CFT30 Intermittent/Erratic: > 6000 rpm/sec change |

| Intermediate Shaft Speed Sensor Functional Check Operation: | |
|---|---|
| DTCs | P0791 – ISS circuit |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 30 seconds |

| Typical ISS functional check entry conditions: | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| Gear selector position | drive | |
| Engine rpm (above converter stall speed) OR | 3000 rpm | |
| Turbine shaft rpm (if available) OR | 1500 rpm | |
| Output shaft rpm | 650 rpm | |
| Vehicle speed (if available) | 15 mph | |

| Typical ISS functional check malfunction thresholds: |
|---|
| Vehicle is inferred to be moving with positive driving torque and ISS < 250 rpm for 5 seconds |

| Turbine Shaft Speed Sensor Functional Check Operation: | |
|---|---|
| DTCs | P0715 – TSS circuit / no signal<br>P0718 – TSS erratic signal |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | OSS, Wheel Speed |
| Monitoring Duration | 30 seconds |

| Typical TSS functional check entry conditions: | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| Gear selector position | Forward range | |
| Engine rpm (above converter stall speed) OR | 3000 rpm | |
| Output shaft rpm OR | 600 - 650 rpm | |
| Vehicle speed (if available) | 12.5 - 15 mph | |

| Typical TSS functional check malfunction thresholds: |
|---|
| Circuit/no signal - vehicle is inferred to be moving with positive driving torque and TSS < 200 rpm for 5 – 30 seconds<br>Erratic signal – observe 200 turbine speed spikes > 400 rpm with no more than 1.5 seconds between spikes |

| Transmission Fluid Temperature Sensor Functional Check Operation: | |
|---|---|
| DTCs (non-MIL) | P0711 – in range failure<br>P0712 – short to ground<br>P0713 – open circuit |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | ECT substituted if TFT has malfunction<br>TFT inferred from pressure solenoids on CFT30 |
| Monitoring Duration | 5 seconds for electrical, 600 seconds for functional check |

| Typical TFT Stuck Low/High check entry conditions: | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| Engine Coolant Temp (hot or cold, not midrange) | > 100 °F | < 20 °F |
| Time in run mode | 500 – 600 sec | |
| Time in gear, vehicle moving, positive torque | 150 sec | |
| Vehicle Speed | 15 mph | |
| Time with engine off (cold start) OR | 420 min | |
| Engine Coolant Temp AND Trans Fluid Temp (inferred cold start) | | 122 °F |

| Typical TFT malfunction thresholds: |
|---|
| Opens/shorts: TFT voltage <0.05 or > 4.6 volts for 5 – 12 seconds<br>TFT Stuck low/high, i.e. TFT stuck at high temperature or stuck at low temperature):<br>Stores a fault code if TFT stabilizes (stops increasing if temperature < 70 deg F, stops decreasing if temperature > 225 deg F) before reaching the temperature region where all MIL tests are enabled (70 to 225 deg F). If TFT remains constant (+/- 2 deg F) for approximately 2.5 minutes of vehicle driving outside the 70 to 225 deg F zone a P0711 fault code will be stored. Old logic used to indicate a "pass" for a single delta, and not test until the normal operating region (70-225 deg F) was reached. |

## Transmission Outputs

| Shift Solenoid Check Operation: | |
|---|---|
| DTCs | SS A - P0750 - open circuit,<br>P0751 – functionally failed off<br>P0752 – functionally failed on<br>P0973 – short to ground<br>P0974 - shorts to power<br>P1714 ISIG functional (4R70 only, replaces P0751, P0752)<br>SS B - P0755 - open circuit<br>P0756 – functionally failed off<br>P0757 – functionally failed on<br>P0976 – short to ground<br>P0977 - shorts to power<br>P1715 ISIG functional (4R70 only, replaces P0756, P0757)<br>SS C - P0760 - open circuit<br>P0761 – functionally failed off<br>P0762 – functionally failed on<br>P0979 – short to ground<br>P0980 - shorts to power<br>SS D P0765 - open circuit<br>P0766 – functionally failed off<br>P0767 – functionally failed on<br>P0982 – short to ground<br>P0983 - shorts to power<br>SS E - P0770 - open circuit<br>P0771 – functionally failed off<br>P0772 – functionally failed on<br>P0985 – short to ground<br>P0986 - shorts to power |
| Monitor execution | electrical - continuous, functional - during off to on solenoid transitions |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 0.5 to 5 seconds for electrical checks, 10 solenoid events for functional check |

| Typical Shift Solenoid ISIG functional check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Transmission Fluid Temp | 70 °F | 225 °F |
| Throttle position | positive drive torque (actual TP varies) | |

| Typical Shift Solenoid mechanical functional check entry conditions: | | |
|---|---|---|
| Entry Conditions (with turbine speed) | Minimum | Maximum |
| Gear ratio calculated | each gear | |
| Throttle position | positive drive torque | |

| Typical Shift Solenoid mechanical functional check entry conditions: | | |
|---|---|---|
| Entry Conditions (without turbine speed) | Minimum | Maximum |
| Rpm drop is obtained | each shift | |
| Throttle position | positive drive torque | |

| Typical Shift Solenoid malfunction thresholds: |
|---|
| Electrical circuit check: Output driver feedback circuit does not match commanded driver state for 0.5 – 5.0 seconds |
| Electrical current check: Feedback current out of range for 0.5 seconds |
| ISIG functional check: ISIG chip hardware circuit does not detect characteristic current dip and rise produced by solenoid movement. |
| Mechanical functional check: Actual obtained gear or shift pattern indicates which shift solenoid is stuck on or off. |

| Gear Ratio Check Operation: | |
|---|---|
| DTCs | P0731 incorrect gear 1 ratio<br>P0732 incorrect gear 2 ratio<br>P0733 incorrect gear 3 ratio<br>P0734 incorrect gear 4 ratio<br>P0735 incorrect gear 5 ratio<br>P0729 incorrect gear 6 ratio<br>P0736 incorrect reverse ratio |
| Monitor execution | Continuous, in each gear |
| Monitor Sequence | None |
| Sensors OK | TSS, OSS, wheel speed |
| Monitoring Duration | 12 seconds |

| Typical Forward Gear Ratio check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Gear selector position | forward range,<br>> 8 seconds | |
| Engine Torque | 100 NM | |
| Throttle position | 10% | |
| Not shifting | > 0.5 seconds | |
| Engine/input Speed | 550 rpm | |
| Output Shaft Speed | 250 rpm | 1350 rpm |

| Typical Neutral Gear Ratio check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Gear selector position | forward range,<br>> 1 second | |
| Absolute value of Engine rpm – Turbine rpm | | 150 rpm |
| Output Shaft Speed | | 500 rpm |

| Typical Gear Ratio malfunction thresholds: |
|---|
| Forward gear check: > 30 error in commanded ratio for > 1.8 seconds that repeats 3 times |

| Torque Converter Clutch Check Operation: | |
|---|---|
| DTCs | P0740 – open circuit<br>P0742 – short to ground<br>P0744 – short to power<br>P0741 – functionally stuck off<br>P2758 – functionally stuck on<br>P1740 – Inductive signature (4R70 only, replaces P0741 / P2758) |
| Monitor execution | electrical - continuous,<br>mechanical - during lockup |
| Monitor Sequence | None |
| Sensors OK | TSS, OSS |
| Monitoring Duration | Electrical – 5 seconds, Functional - 5 lock-up events |

| Typical TCC ISIG functional check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Transmission Fluid Temp | 70 °F | 225 °F |
| Engine Torque | positive drive torque | |
| Commanded TCC duty cycle for 0 rpm slip | 60% | 90% |

| Typical TCC mechanical functional check stuck off entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Throttle Position | steady | |
| Engine Torque | positive drive torque | |
| Transmission Fluid Temp | 70 °F | 225 °F |
| Commanded TCC duty cycle (0 rpm slip) | 60% | 100% |
| Not shifting | | |

| Typical TCC malfunction thresholds: |
|---|
| Electrical circuit check: Output driver feedback circuit does not match commanded driver state for 0.5 – 5.0 seconds<br>Electrical current check: Feedback current out of range for 0.5 seconds<br>ISIG functional check: ISIG chip hardware circuit does not detect characteristic current dip and rise produced by solenoid movement.<br>Mechanical check, stuck off: Slip across torque converter > 100 – 200 rpm or speed ratio < 0.93<br>Mechanical check, stuck on: Slip across torque converter < 20 rpm with converter commanded off<br>Mechanical check, stuck on: engine rpm < 100 after drive engagement (engine stall) |

| Pressure Control Solenoid Check Operation: | |
|---|---|
| DTCs | P0960 – open circuit<br>P0962 – short to ground<br>P0963 – short to power |
| Monitor execution | Continuous |
| Monitor Sequence | none |
| Sensors OK | |
| Monitoring Duration | Electrical: 5 seconds,<br>Mechanical functional: up to 30 seconds |

| Typical Pressure Control Solenoid mechanical functional check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Gear ratio calculated | each gear | |
| Transmission Fluid Temperature | 70 $^{o}$F | 225 $^{o}$F |
| Throttle Position | positive drive torque | |

| Typical Pressure Control Solenoid malfunction thresholds: |
|---|
| Electrical circuit check: Output driver feedback circuit does not match commanded driver state for 0.5 – 5.0 seconds<br>Electrical current check: Feedback current out of range for 0.5 seconds<br>Mechanical functional check: Actual obtained gear pattern indicates Pressure Control solenoid fault |

| Inductive Signature Chip Communication Check Operation: | |
|---|---|
| DTCs | P1636 ISIG chip loss of communication |
| Monitor execution | off-to-on solenoid transitions |
| Monitor Sequence | none |
| Sensors OK | |
| Monitoring Duration | < 100 solenoid events |

| Typical Inductive Signature Chip Communication Check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Transmission Fluid Temp | 70 °F | 225 °F |
| Solenoid commanded off duration | | < 2 seconds |

| Typical Inductive Signature Communication Chip malfunction thresholds: |
|---|
| Checksum error, chip not responding |

# 4R75E (RWD) Transmission

4R75E is the replacement for the 4R70W. The 4R75E transmission is essentially a 4R70W with a Turbine Speed Sensor (TSS)

## Transmission Inputs

The Digital Transmission Range (DTR) sensor provides a single analog and three digital inputs to the PCM. The PCM decodes the inputs to determine the driver-selected gear position (Park, Rev, Neutral, OD, 2, 1). This input device is checked for opens and invalid input patterns. (P0708 P0705)

The Vehicle Speed Sensor (VSS), Output Shaft Speed (OSS) sensor, and Turbine Speed Sensor (TSS) if equipped, are inputs that are checked for rationality. If the engine rpm is above the torque converter stall speed and engine load is high, it can be inferred that the vehicle must be moving. If there is insufficient output from the VSS sensor, a malfunction is indicated (P0500). If there is insufficient output from the OSS sensor, a malfunction is indicated (P0720). If there is insufficient output from the TSS sensor, a malfunction is indicated (P0715).

## Transmission Outputs

### Shift Solenoids

The Shift Solenoid (SSA and SSB) output circuits are checked for opens and shorts by the PCM by monitoring the status of a feedback circuit from the output driver (P0750 SSA, P0755 SSB).

All vehicle applications will utilize an inductive signature circuit to monitor the shift solenoids functionally. The ISIG circuit monitors the current signature of the shift solenoid as the solenoid is commanded on. A solenoid that functions properly will show a characteristic decrease in current as the solenoid starts to move. If the solenoid is malfunctioning, the current will not change (P1714 SSA, P1715 SSB). The lack of communication between the ISIG chip and the PCM microprocessor is also monitored (P1636).

### Torque Converter Clutch

The Torque Converter Clutch (TCC) output circuit is a duty-cycled output that is checked electrically for opens and shorts by the PCM by monitoring the status of a feedback circuit from the output driver (P0743).

All vehicle applications will utilize an inductive signature circuit to monitor the torque converter clutch. The ISIG circuit monitors the current signature of the TCC solenoid as the solenoid is commanded on. A solenoid that functions properly will show a characteristic decrease in current as the solenoid starts to move. If the solenoid is malfunctioning, the current will not change (P1740). In some applications, the ISIG test is run in conjunction with the other transmission functional tests. The lack of communication between the ISIG chip and the PCM microprocessor is also monitored (P1636).

### Electronic Pressure Control

The EPC solenoid is a variable force solenoid that controls line pressure in the transmission. The EPC solenoid has a feedback circuit in the PCM that monitors EPC current. If the current indicates a short to ground (low pressure), engine torque may be reduced to prevent damage to the transmission. (P0962, PCA)

## Transmission Inputs

### Transmission Range Sensor

The Non-contacting Pulse Width Modulated Transmission Range Sensor (TRS) provides a duty cycle signal for each position. This signal is transmitted at a frequency of 125 Hz. The PCM decodes the duty cycle to determine the driver-selected gear position (Park, Rev, Neutral, OD, 3, 2, 1). This input device is checked for out of range frequency, low duty cycle and high duty cycle input signals. (P0706, P0707, P0708)

### Speed Sensors

The Turbine Shaft Speed (TSS) sensor, Intermediate Shaft Speed (ISS) sensor and Output Shaft Speed (OSS) sensor, if equipped, are hall effect inputs that are checked for rationality. The vehicle speed signal is provided from the ABS system to the PCM. If the engine rpm is above the torque converter stall speed and engine load is high, it can be inferred that the vehicle must be moving. If there is insufficient output from the VSS sensor, a malfunction is indicated (P0500). If there is insufficient output from the TSS sensor, a malfunction is indicated (P0715). If there is insufficient output from the ISS sensor, a malfunction is indicated (P0791). If there is insufficient output from the OSS sensor, a malfunction is indicated (P0720).

### Transmission Fluid Temperature

5R110W has a feature called "Cold mode". If TFT is below 0 deg F, the transmission will limit operation to 1$^{st}$, 2$^{nd}$, 3$^{rd}$, and 4$^{th}$ gears (5$^{th}$ and 6$^{th}$ gears are disabled). Cold mode remains in effect until TFT rises above 0 deg F or vehicle operation (based on shift times or heat generated by driving) indicates that TFT should not be in the cold mode range, at which point normal operation is enabled.

Direct clutch apply times cold have forced the addition of this cold mode (DC takes excessive times to apply below –10 deg F), and require revisions to TFT failure management – if TFT is failed at start up the transmission will be placed in cold mode and remain there until TFT is no longer failed and above 0 deg F or the vehicle operating conditions listed above trigger an exit from cold mode.

Once out of cold mode a TFT failure will not trigger cold mode (can only go into cold mode once/power-up); but this mode is new to 5R110W.

TFT is monitored for circuit faults (P0712, P0713) and in-range failures (P0711)

For this reason all TFT diagnostics illuminate the MIL on 5R110W.

## Transmission Outputs

### Shift Solenoids

The Shift Solenoid (SSA, SSB, SSC, SSD, and SSE) output circuits are checked for opens and shorts by the PCM by monitoring the status of a feedback circuit from the output driver (SSA P0750, P0973, P0974; SSB P0755, P0976, P0977; SSC P0760, P0979, P0980; SSD P0765, P0982, P0983; SSE P0770, P0985, P0986).

The shift solenoids will be tested for function. This is determined by vehicle inputs such as gear command, and gear. Shift solenoid malfunction codes actually cover the entire clutch system (using ratio there is no way to isolate the solenoid from the rest of the clutch system. Diagnostics will isolate the fault into clutch functionally (non-electrical) failed off (SSA P0751, SSB P0756, SSC P0761, SSD P0766, SSE P0771) and clutch functionally failed on (SSA: P0752, SSB: P0757, SSC: P0762, SSD: P0767, SSE: P0772). These fault codes replace the P2700 level clutch fault codes previously used since the additional information of the failed state of the clutch adds value for service.

### Torque Converter Clutch

The Torque Converter Clutch (TCC) output circuit is a duty-cycled output that is checked electrically for opens and shorts internally in the PCM by monitoring the status of a feedback circuit from the output driver (P0740, P0742, P0744).

The TCC solenoid is checked functionally by evaluating torque converter slip under steady state conditions when the torque converter is fully applied. If the slip exceeds the malfunction thresholds when the TCC is commanded on, a TCC malfunction is indicated (P0741).

### Electronic Pressure Control

The EPC solenoid is a variable force solenoid that controls line pressure in the transmission. The EPC solenoid has a feedback circuit in the PCM that monitors EPC current. If the current indicates a short to ground (low pressure), a high side switch will be opened. This switch removes power from all 7 VFSs, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position. This solenoid is tested for open (P0960), short to ground (P0962), and short to power (P0963) malfunctions.

### High Side Switch

5R110W has a high side switch that can be used to remove power from all 7 VFSs simultaneously. If the high side switch is opened, all 7 solenoids will be electrically off, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position. The switch is tested for open faults (switch failed closed will provide normal control). If the switch fails, a P0657 fault code will be stored.

### CAN Communications error

The TCM receives critical information from the ECM via CAN. If the CAN link fails, the TCM no longer has torque or engine speed information available – the high side switch will be opened. The TCM will store a U0100 fault code if unable to communicate with the TCM.

## Requirements for Heavy-Duty Engine Testing

Beginning in 2005, Ford is introducing a new TorqShift (5R110W) transmission for all HDGE automatic transmission applications. This new transmission uses direct electronic shift control technology (DESC) to actuate transmission mechanisms to achieve the desired gear changes. The DESC architecture requires more extensive monitoring within the PCM of transmission components, speeds, and gear ratios to ensure that the transmission is operating within expected ranges. Without the transmission hardware present during engine dyno testing, the transmission diagnostics will presume a transmission/sensor failure, and default to self-protective operating mode. As in past years, this requires special test procedures to be used during HDGE testing to assure a representative test by simulating key signals typically generated from the transmission system. The methodology used to generate these signals has been modified for the 2005MY.

For dynamometer testing on engines using this new transmission, the function of the previously used simulator box is now incorporated as part of the transmission OBD code included in the power-train control module (PCM). The new simulator strategy expands on the old strategy and uses engine rpm, commanded gear, and manual lever position to model transmission control system responses, e.g. representative, scheduled shift points and torque modulation during shifts. The PCM will enter this 'dyno cert' mode if, at start up, the transmission OBD senses that the seven transmission variable force solenoids, the turbine speed sensor, the intermediate speed sensor, and the output speed sensor are all absent. In this mode, transmission diagnostics are disabled, a MIL code is set, and the PCM generates simulated signals that typically come from the transmission.

During the running of the transient dyno cycle, the engine follows a set path of normalized engine rpm and normalized torque as prescribed in the regulations. This simulator strategy allows the engine to perform this cycle, with the PCM reacting as if the transmission were present and the vehicle were operating on the road, resulting in representative shift events and torque modulation. These shift events follow the calibrated shift schedule, but require the input of specific transmission signals. These signals include Turbine Shaft Speed (TSS), Intermediate Shaft Speed (ISS), Output Shaft Speed (OSS), and Vehicle Speed (VSS). Since there is no transmission hardware, these signals must be simulated. The model for the simulation strategy is based on fixed mechanical gear ratios of the transmission, scheduled shift points; small losses of efficiency in the torque converter, and approximations of transmission characteristics during transition periods (i.e. shift transition between 1st & 2nd gears). Simulated characteristics during shifts are based on extensive experience with real world transmission and vehicle operation. The initial inputs to the simulator are engine speed and transmission lever position (e.g. park, drive), these signals determine the status of the Torque Converter Clutch, and in turn output the TSS. In park, TSS equals engine rpm. In drive with the engine speed less than an approximate engine speed of 1000 rpm, the TSS equal zero. As the engine accelerates (or decelerates), the model ramps the TSS signal to respond as closely as possible to the way the turbine shaft would respond on the road. The TSS in turn, along with the status of the overdrive gear set, is used to generate the ISS. This is based on the commanded gear, and fixed gear ratios. During shift events, the model ramps the ISS signal between gear ratios. Likewise, ISS is then used, with the status of the simpson gear set, to generate the OSS, based on the fixed gear ratios. OSS is in turn used by the PCM to establish commanded gear. VSS is calculated from the OSS, using tire size and axle ratio. VSS is used within the PCM for vehicle speed limiting and as an entry condition to some of the engine on-board diagnostics.

The goal of this new 'simulator' strategy is to ensure proper function of the PCM without transmission hardware. Only the transmission OBD recognizes that the engine is in 'dyno cert' mode, the rest of the transmission control systems react as if the transmission hardware is present and is running normally as it would on the road.

# 6R80 (RWD) Transmission with external PCM or TCM

## Transmission Control System Architecture

Starting in 2010.5 MY 6R80 is transitioning from an internal TCM to an external PCM (gas applications) or TCM (Diesel applications). Main hardware differences:

- Transmission Range Sensor still 4 bit digital, but the transmission bulkhead connector could not accommodate 4 pins so a micro processor was added to the sensor. This processor converts the 4 bit digital signal into a Pulse Width Modulated (PWM) 125 Hz signal.

- Module temperature sensor has been deleted.

The 6R80 is a 6-speed, step ratio transmission that is controlled by an external PCM (gas engine applications) or TCM (Diesel engine applications). For Diesel the TCM communicates to the Engine Control Module (ECM), ABS Module, Instrument Cluster and Transfer Case Control Module using the high speed CAN communication link. The TCM incorporates a standalone OBD-II system. The TCM independently processes and stores fault codes, freeze frame, supports industry-standard PIDs as well as J1979 Mode 09 CALID and CVN. The TCM does not directly illuminate the MIL, but requests the ECM to do so. The TCM is located outside the transmission assembly. It is not serviceable with the exception of reprogramming.

## Transmission Inputs

### Transmission Range Sensor

Due to transmission bulkhead connector issues the 4 bit digital TRS used by 6R80 with an internal TCM has been revised. The sensor now contains a micro processor that converts the 4 bit digital signal from into a Pulse Width Modulated (PWM) 125 Hz signal that is then output to the PCM. The sensor outputs a specific duty cycle for each bit pattern, including the invalid bit patterns. TRS is tested for invalid bit pattern (P0705 – inferred by the PCM thru the duty cycle), frequency out of range (P0706), duty cycle out of range low (P0707), duty cycle out of range high (P0708).

### Speed Sensors

The Turbine Shaft Speed (TSS) sensor and Output Shaft Speed (OSS) sensor are Hall effect sensors.

The Turbine Shaft Speed sensor is monitored for circuit faults and rationality (P0715, P0717). If turbine shaft speed exceeds a maximum calibrated speed (7,700 rpm), a fault is stored (P0716). If engine speed and output shaft speed are high and a gear is engaged, it can be inferred that the vehicle is moving. If there is insufficient output from the TSS sensor a fault is stored (P0716).

The Output Shaft Speed sensor is monitored for circuit faults and rationality (P0720, P0722). If output shaft speed exceeds a maximum calibrated speed (7,450 rpm), a fault is stored (P0721). If output shaft speed does not correlate with turbine shaft speed and wheel speed while a gear is engaged and the vehicle is moving, a fault is stored (P0721). If the output shaft speed decreases at an erratic/unreasonable rate, a fault is stored (P0723).

### Transmission Fluid Temperature

The Transmission Fluid Temperature Sensor is checked for open circuit, short circuit to ground, short circuit to power, and in-range failures (P0711, P0712, P0713, P0714). In-range TFT (P0711) is now the Ford standard diagnostic – the internal TCM temperature sensor is no longer available to diagnose TFT failures.

## Transmission Outputs

### Shift Solenoids

6R80 has 5 shift solenoids:

1. SSA – a Variable Force Solenoid (VFS) that controls CB1234 (a brake clutch, grounds an element to the case, that is on in 1$^{st}$, 2$^{nd}$, 3$^{rd}$ and 4$^{th}$ gear)

2. SSB – a VFS that controls C35R (a rotating clutch on in 3$^{rd}$, 5$^{th}$ and Reverse)

3. SSC – a VFS that controls CB26 (a brake clutch on in 2$^{nd}$ and 6$^{th}$ gear)

4. SSD – a VFS that controls either CBLR (a brake clutch on in 1$^{st}$ gear with engine braking and Reverse) or C456 (a rotating clutch on in 4$^{th}$, 5$^{th}$ and 6$^{th}$ gear)

5. SSE – an On/Off solenoid that controls the multiplexing of SSD between CBLR and C456.

Output circuits are checked for opens, short to ground and short to power faults (codes listed in that order) by the PCM by monitoring the status of a feedback circuit from the output driver (SSA P0750, P0973, P0974; SSB P0755, P0976, P0977; SSC P0760, P0979, P0980; SSD P0765, P0982, P0983; SSE P0770).

The shift solenoids are also functional tested for stuck on and stuck off failures. This is determined by vehicle inputs such as gear command, and achieved gear (based on turbine and output speed). In general the shift solenoid malfunction codes actually cover the entire clutch system (solenoid, valves, and the clutch itself) since using ratio there is no way to isolate the solenoid from the rest of the clutch system

For SSA thru SSD Diagnostics will isolate the fault into clutch functionally (non-electrical) failed off (SSA P0751, SSB P0756, SSC P0761, SSD P0766) and clutch functionally failed on (SSA: P0752, SSB: P0757, SSC: P0762, SSD: P0767). The On/Off solenoid (SSE) controls the multiplexing of SSD between CBLR and C456 clutches. Using ratio we can determine if the multiplex valve is in the wrong position, but cannot be sure if the failure is due to the solenoid or a stuck valve. The multiplex valve is tested for stuck in default position (P0771, includes SSE stuck off) and stuck in spring compressed position (P0772, includes SSE stuck on) failures.

### Gear ratio errors:

If ratio errors are detected that do not match an expected pattern for a failed solenoid then gear ratio error fault codes (1$^{st}$ gear – P0731, 2$^{nd}$ gear – P0732, 3$^{rd}$ gear – P0733, 4$^{th}$ gear – P0734, 5$^{th}$ gear – P0735 or 6$^{th}$ gear – P0729) will be stored.

## Torque Converter Clutch

The Torque Converter Clutch (TCC) Solenoid output circuit is a duty-cycled output that is checked electrically for open circuit, short circuit to ground, and short circuit to power by monitoring the status of a feedback circuit from the output driver (P0740, P2763, P2764). If the TCC pressure is high and the engine torque is low, the TCC should be fully applied or have a controlled amount of slippage. If the slip exceeds a threshold, a fault is stored (P0741).

## Pressure Control

The Pressure Control solenoid is a variable force solenoid that controls line pressure in the transmission. The Pressure Control solenoid output circuit is a duty-cycled output that is checked electrically for short circuit to ground or short circuit to battery by monitoring the status of a feedback circuit from the output driver (P0962, P0963).

Note that the Pressure Control Solenoid failures P0960 and P0963 do not illuminate the MIL because the diagnostic action (maximum line pressure) does not affect emissions.

## High Side Actuator Control Circuit

The TCM has a high side actuator supply control circuit that can be used to remove power from all 7 solenoids and the external Reverse Light Relay simultaneously. If the high side actuator control circuit is deactivated, all 7 solenoids and the external Reverse Light Relay will be electrically turned off, providing Park, Reverse, Neutral, and 3M/5M (in all forward ranges) with maximum line pressure, based on the selected transmission range. The actuator control circuit is tested for open circuits. (P0657).

ADLER (chip that controls all 7 solenoids) diagnostics:

The solenoids are controlled by an ADLER chip. The main micro sends commanded solenoid states to the ADLER, and receives back solenoid circuit fault information.

If communication with the ADLER is lost a P1636 fault code will be stored. If this failure is detected the states of the solenoids are unknown, so the control system will open the high side switch (removes power from all the solenoids), providing P, R, N and 5M with open TCC and max line pressure.

TRID Block

The TRID block is a portion of flash memory that contains solenoid characterization data tailored to the specific transmission to improve pressure accuracy.

The TRID block is monitored for two failures:

a) TRID block checksum error / incorrect version of the TRID (P163E)

b) TRID block not programmed (P163F)

If the TRID block is unavailable FMEM action limits operation to 1st and 3rd gear until the issue is correct.

## Transmission Control Module (TCM – Diesel only)

The TCM has the same module diagnostics as a PCM – see miscellaneous CPU tests.

### CAN Communications Error

The TCM receives information from the ECM via the high speed CAN network. If the CAN link or network fails, the TCM no longer has torque or engine speed information available. The TCM will store a U0073 fault code and will illuminate the MIL immediately (missing engine speed) if the CAN Bus is off. The TCM will store a U0100 fault code and will illuminate the MIL immediately (missing engine speed) if it stops receiving CAN messages from the ECM. A U0401 fault codes will be stored if the ECM sends invalid/faulted information for the following CAN message items: engine torque, pedal position.

### TCM voltage

If the system voltage at the TCM is outside of the specified 9 to 16 volt range, a fault will be stored (P0882, P0883).

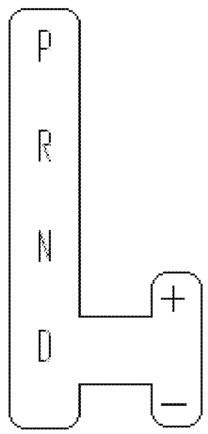
## Transmission Inputs

### Transmission Range Sensor

The 6F Digital Transmission Range (DTR) sensor provides four digital inputs to the PCM. Unlike the Ford standard digital TRS that has 1 analog and 3 digital inputs, this sensor uses 4 digital inputs, and all switches open (sensor disconnect) is an invalid bit pattern. The PCM decodes these inputs to determine the driver-selected gear position (Park, Rev, Neutral, OD, Low). This input device is checked for all switches open (P0708), invalid input patterns (P0705), and a stuck in transition zone between valid positions (P0706).

### Select Shift Transmission (SST) Up/Down

6F is picking up SST for 09 MY. This system has two new PCM inputs, an upshift switch and a downshift switch. The switches are built into the shifter (defined as an H-gate in this implementation):




Both PCM inputs are open when the shifter is on the left hand side. From Drive as the customer moves the shifter to the right both inputs transition from open to closed (the TRS continues to indicate Drive). The control system enters "Grade Assist Mode" (provides more engine braking but still follows an automatic shift schedule) at this point. If the customer never requests a shift the control system will remain in Grade Assist Mode.

The customer requests a shift by pushing the shifter up or down, which opens the appropriate switch. Once the customer requests a shift the control system transitions from Grade Assist Mode to SST. In SST the control system follows the customer's commands except for special conditions (downshifts to the lowest available gear at high pedal, downshifts at low speeds).

Diagnostics monitors for either switch closed in Park, Reverse or Neutral, and a failure will result in non-MIL P0815 (upshift switch error) or P0816 (downshift switch error) fault codes.

If either switch fails open the customer will not be able to enter Grade Mode or SST since both switches must transition from open to closed while in the Drive position to enter SST.

If either switch is detected failed Grade Assist Mode and SST are disabled and the control system defaults to Drive (normal automatic shift schedules).

### Speed Sensors

The Turbine Shaft Speed (TSS) sensor and Output Shaft Speed (OSS) sensor are Hall Effect inputs that are checked for rationality. The vehicle speed signal is provided from the ABS system (if present) to the PCM, or is derived from OSS. If the engine rpm is above the torque converter stall speed and engine load is high, it can be inferred that the vehicle must be moving. If there is insufficient output from the VSS sensor (if present), a malfunction is indicated (P0500). If there is insufficient output from the TSS sensor, a malfunction is indicated (P0715). If there is insufficient output from the OSS sensor, a malfunction is indicated (P0720).

### Transmission Fluid Temperature

6F has a feature called "Cold mode" (1st implemented in 5R110W in 2003 MY). If TFT is below -20 deg F, the transmission will limit operation to 1st, 2nd, 3rd, and 4th gears (5th and 6th gears are disabled). Cold mode remains in effect until TFT rises above -20 deg F or vehicle operation (based on shift times or heat generated by driving) indicates that TFT should not be in the cold mode range, at which point normal operation is enabled.

if TFT is failed at start up the transmission will be placed in cold mode and remain there until TFT is no longer failed and above -20 deg F or the vehicle operating conditions listed above trigger an exit from cold mode.

Once out of cold mode a TFT failure will not trigger cold mode (can only go into cold mode once/power-up); this mode is the same as implemented on 5R110W in 2003.5 MY.

TFT is monitored for circuit faults (P0712, P0713) and in-range failures (P0711)

For this reason all TFT diagnostics illuminate the MIL on 6F.

## Transmission Outputs

### Shift Solenoids

6F has 5 shift solenoids:

- SSA – a Variable Force Solenoid (VFS) that controls CB1234 (a brake clutch, grounds an element to the case, that is on in 1st, 2nd, 3rd and 4th gear)
- SSB – a VFS that controls C35R (a rotating clutch on in 3rd, 5th and Reverse)
- SSC – a VFS that controls CB26 (a brake clutch on in 2nd and 6th gear)
- SSD – a VFS that controls either CBLR (a brake clutch on in 1st gear with engine braking and Reverse) or C456 (a rotating clutch on in 4th, 5th and 6th gear)
- SSE – an On/Off solenoid that controls the multiplexing of SSD between CBLR and C456.

Output circuits are checked for opens, short to ground and short to power faults (codes listed in that order) by the PCM by monitoring the status of a feedback circuit from the output driver (SSA P0750, P0973, P0974; SSB P0755, P0976, P0977; SSC P0760, P0979, P0980; SSD P0765, P0982, P0983; SSE P0770).

The shift solenoids are also functional tested for stuck on and stuck off failures. This is determined by vehicle inputs such as gear command, and achieved gear (based on turbine and output speed). In general the shift solenoid malfunction codes actually cover the entire clutch system (solenoid, valves, and the clutch itself since using ratio there is no way to isolate the solenoid from the rest of the clutch system), BUT due to the hydraulic controls arrangement on 6F it is possible to isolate two specific solenoid failures from clutch system faults:

a) SSB stuck on from C35R stuck on - due to hydraulic interlock between CBLR and C35R we can isolate SSB stuck on from C35R by turning SSE on in 1st gear without engine braking (get 1st if SSB stuck on, get 3rd if C35R is stuck on)

b) SSD stuck off. Since SSD is multiplexed (controls both CBLR and C456) we can isolate CBLR stuck off and C456 stuck off from SSD stuck off since the latter impacts both clutch systems.

For SSA thru SSD Diagnostics will isolate the fault into clutch functionally (non-electrical) failed off (SSA P0751, SSB P0756, SSC P0761, SSD P0766) and clutch functionally failed on (SSA: P0752, SSB: P0757, SSC: P0762, SSD: P0767). The On/Off solenoid (SSE) controls the multiplexing of SSD between CBLR and C456 clutches. Using ratio we can determine if the multiplex valve is in the wrong position, but cannot be sure if the failure is due to the solenoid or a stuck valve. The multiplex valve is tested for stuck in default position (P0771, includes SSE stuck off) and stuck in spring compressed position (P0772, includes SSE stuck on) failures.

## Torque Converter Clutch

The Torque Converter Clutch (TCC) solenoid is a Variable Force Solenoid. TCC solenoid circuit is checked electrically for open, short to ground and short to power circuit faults internally in the PCM by monitoring the status of a feedback circuit from the output driver (P0740, P0742, P0744).

The TCC solenoid is checked functionally by evaluating torque converter slip under steady state conditions when the torque converter is fully applied. If the slip exceeds the malfunction thresholds when the TCC is commanded on, a TCC malfunction is indicated (P0741).

For 6F the TCC is controlled by a 2 valve system - TCC reg apply and TCC control valve. Normally the TCC VFS controls the positions of these valves - turning on the TCC VFS moves both valves from the release to the apply position. If the TCC control valve sticks in the apply position then there will be no flow thru the TCC (both apply and release sides exhausted) when commanded open, which will cause the converter to overheat.

A method to detect this failure was designed into the hardware - SSE pressure is routed to the TCC reg apply valve (SSE has no effect on TCC control valve). In 3rd gear or higher if TCC is open SSE can be turned on, moving the TCC reg apply valve to the apply position. If the TCC control valve is in the wrong (apply) position this will cause the TCC to apply. If the TCC applies when SSE is turned on in 3rd, 4th, 5th or 6th gear while TCC is commanded open (TCC VFS pressure low) the failure will be detected, a P2783 DTC fault code stored. Even though this test only detects failures of the control valve, the FMEM actions alter the shift and TCC lock schedules to keep the TCC applied as much as possible, so this failure has been made MIL.

## Electronic Pressure Control

The EPC solenoid is a variable force solenoid that controls line pressure in the transmission. The EPC solenoid has a feedback circuit in the PCM that monitors EPC current. If the current indicates a short to ground (low pressure), a high side switch will be opened. This switch removes power from all 6 VFSs and the on/off shift solenoid, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position. This solenoid is tested for open (P0960), short to ground (P0962), and short to power (P0963) malfunctions.

## High Side Switch

6F has a high side switch that can be used to remove power from all 7 solenoids simultaneously. If the high side switch is opened, all 7 solenoids will be electrically off, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position. The switch is tested for open faults (switch failed closed will provide normal control). If the switch fails, a P0657 fault code will be stored.

ADLER (chip that controls all 7 solenoids) diagnostics:

The solenoids are controlled by an ADLER chip. The main micro sends commanded solenoid states to the ADLER, and receives back solenoid circuit fault information.

If communication with the ADLER is lost a P1636 fault code will be stored. If this failure is detected the states of the solenoids are unknown, so the control system will open the high side switch (removes power from all the solenoids), providing P, R, N and 5M with open TCC and max line pressure.

TRID Block

The TRID block is a portion of flash memory that contains solenoid characterization data tailored to the specific transmission to improve pressure accuracy.

The TRID block is monitored for two failures:

- TRID block checksum error / incorrect version of the TRID (P163E)
- TRID block not programmed (P163F)

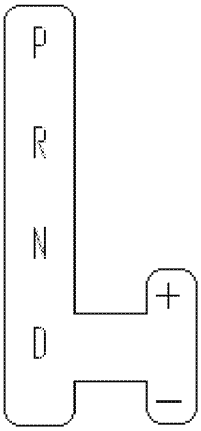
If the TRID block is unavailable FMEM action limits operation to 1$^{st}$ and 3$^{rd}$ gear until the issue is correct.

## Transmission Inputs

Transmission Range Sensor – 6F35 uses a Non-contacting Pulse Width Modulated Transmission Range Sensor (TRS) that provides a duty cycle signal for each position. This signal is transmitted at a frequency of 125 Hz. The PCM decodes the duty cycle to determine the driver-selected gear position (Park, Rev, Neutral, OD, 3, 2, 1). This input device is checked for out of range frequency, low duty cycle and high duty cycle input signals. (P0706, P0707, P0708)

### Select Shift Transmission (SST) Up/Down

6F35 is picking up SST for 10 MY. This system has two new PCM inputs, an upshift switch and a downshift switch. The switches are built into the shifter (defined as an H-gate in this implementation):




Both PCM inputs are open when the shifter is on the left hand side. From Drive as the customer moves the shifter to the right both inputs transition from open to closed (the TRS continues to indicate Drive). The control system enters "Grade Assist Mode" (provides more engine braking but still follows an automatic shift schedule) at this point. If the customer never requests a shift the control system will remain in Grade Assist Mode.

The customer requests a shift by pushing the shifter up or down, which opens the appropriate switch. Once the customer requests a shift the control system transitions from Grade Assist Mode to SST. In SST the control system follows the customer's commands except for special conditions (downshifts to the lowest available gear at high pedal, downshifts at low speeds).

Diagnostics monitors for either switch closed in Park, Reverse or Neutral, and a failure will result in non-MIL P0815 (upshift switch error) or P0816 (downshift switch error) fault codes.

If either switch fails open the customer will not be able to enter Grade Mode or SST since both switches must transition from open to closed while in the Drive position to enter SST.

If either switch is detected failed Grade Assist Mode and SST are disabled and the control system defaults to Drive (normal automatic shift schedules).

### Speed Sensors

The Turbine Shaft Speed (TSS) sensor and Output Shaft Speed (OSS) sensor are Hall Effect inputs that are checked for rationality. The vehicle speed signal is provided from the ABS system (if present) to the PCM, or is derived from OSS. If the engine rpm is above the torque converter stall speed and engine load is high, it can be inferred that the vehicle must be moving. If there is insufficient output from the VSS sensor (if present), a malfunction is indicated (P0500). If there is insufficient output from the TSS sensor, a malfunction is indicated (P0715). If there is insufficient output from the OSS sensor, a malfunction is indicated (P0720).

### Transmission Fluid Temperature

6F35 has a feature called "Cold mode" (1$^{st}$ implemented in 5R110W in 2003 MY). If TFT is below -20 deg F, the transmission will limit operation to 1$^{st}$, 2$^{nd}$, 3$^{rd}$, and 4$^{th}$ gears (5$^{th}$ and 6$^{th}$ gears are disabled). Cold mode remains in effect until TFT rises above -20 deg F or vehicle operation (based on shift times or heat generated by driving) indicates that TFT should not be in the cold mode range, at which point normal operation is enabled.

if TFT is failed at start up the transmission will be placed in cold mode and remain there until TFT is no longer failed and above -20 deg F or the vehicle operating conditions listed above trigger an exit from cold mode.

Once out of cold mode a TFT failure will not trigger cold mode (can only go into cold mode once/power-up); this mode is the same as implemented on 5R110W in 2003.5 MY.

TFT is monitored for circuit faults (P0712, P0713) and in-range failures (P0711)

For this reason all TFT diagnostics illuminate the MIL on 6F35.

## Transmission Outputs

### Shift Solenoids

6F has 5 shift solenoids:

a. SSA – a Variable Force Solenoid (VFS) that controls CB1234 (a brake clutch, grounds an element to the case, that is on in 1$^{st}$, 2$^{nd}$, 3$^{rd}$ and 4$^{th}$ gear)

b. SSB – a VFS that controls C35R (a rotating clutch on in 3$^{rd}$, 5$^{th}$ and Reverse)

c. SSC – a VFS that controls CB26 (a brake clutch on in 2$^{nd}$ and 6$^{th}$ gear)

d. SSD – a VFS that controls either CBLR (a brake clutch on in 1$^{st}$ gear with engine braking and Reverse) or C456 (a rotating clutch on in 4$^{th}$, 5$^{th}$ and 6$^{th}$ gear)

e. SSE – an On/Off solenoid that controls the multiplexing of SSD between CBLR and C456.

Output circuits are checked for opens, short to ground and short to power faults (codes listed in that order) by the PCM by monitoring the status of a feedback circuit from the output driver (SSA P0750, P0973, P0974; SSB P0755, P0976, P0977; SSC P0760, P0979, P0980; SSD P0765, P0982, P0983; SSE P0770).

The shift solenoids are also functional tested for stuck on and stuck off failures. This is determined by vehicle inputs such as gear command, and achieved gear (based on turbine and output speed). In general the shift solenoid malfunction codes actually cover the entire clutch system (solenoid, valves, and the clutch itself since using ratio there is no way to isolate the solenoid from the rest of the clutch system), BUT due to the hydraulic controls arrangement on 6F it is possible to isolate two specific solenoid failures from clutch system faults:

1. SSB stuck on from C35R stuck on - due to hydraulic interlock between CBLR and C35R we can isolate SSB stuck on from C35R by turning SSE on in 1$^{st}$ gear without engine braking (get 1$^{st}$ if SSB stuck on, get 3$^{rd}$ if C35R is stuck on)

2. SSD stuck off. Since SSD is multiplexed (controls both CBLR and C456) we can isolate CBLR stuck off and C456 stuck off from SSD stuck off since the latter impacts both clutch systems.

For SSA thru SSD Diagnostics will isolate the fault into clutch functionally (non-electrical) failed off (SSA P0751, SSB P0756, SSC P0761, SSD P0766) and clutch functionally failed on (SSA: P0752, SSB: P0757, SSC: P0762, SSD: P0767). The On/Off solenoid (SSE) controls the multiplexing of SSD between CBLR and C456 clutches. Using ratio we can determine if the multiplex valve is in the wrong position, but cannot be sure if the failure is due to the solenoid or a stuck valve. The multiplex valve is tested for stuck in default position (P0771, includes SSE stuck off) and stuck in spring compressed position (P0772, includes SSE stuck on) failures.

### Gear ratio errors:

If ratio errors are detected that do not match an expected pattern for a failed solenoid then gear ratio error fault codes (1$^{st}$ gear – P0731, 2$^{nd}$ gear – P0732, 3$^{rd}$ gear – P0733, 4$^{th}$ gear – P0734, 5$^{th}$ gear – P0735 or 6$^{th}$ gear – P0729) will be stored.

### Torque Converter Clutch

The Torque Converter Clutch (TCC) solenoid is a Variable Force Solenoid. TCC solenoid circuit is checked electrically for open, short to ground and short to power circuit faults internally in the PCM by monitoring the status of a feedback circuit from the output driver (P0740, P0742, P0744).

The TCC solenoid is checked functionally by evaluating torque converter slip under steady state conditions when the torque converter is fully applied. If the slip exceeds the malfunction thresholds when the TCC is commanded on, a TCC malfunction is indicated (P0741).

For 6F35 the TCC is controlled by a 2 valve system - TCC reg apply and TCC control valve. Normally the TCC VFS controls the positions of these valves - turning on the TCC VFS moves both valves from the release to the apply position. If the TCC control valve sticks in the apply position then there will be no flow thru the TCC (both apply and release sides exhausted) when commanded open, which will cause the converter to overheat.

A method to detect this failure was designed into the hardware - SSE pressure is routed to the TCC reg apply valve (SSE has no effect on TCC control valve). In 3rd gear or higher if TCC is open SSE can be turned on, moving the TCC reg apply valve to the apply position. If the TCC control valve is in the wrong (apply) position this will cause the TCC to apply. If the TCC applies when SSE is turned on in 3$^{rd}$, 4$^{th}$, 5$^{th}$ or 6$^{th}$ gear while TCC is commanded open (TCC VFS pressure low) the failure will be detected, a P2783 DTC fault code stored. Even though this test only detects failures of the control valve, the FMEM actions alter the shift and TCC lock schedules to keep the TCC applied as much as possible, so this failure has been made MIL.

### Electronic Pressure Control

The EPC solenoid is a variable force solenoid that controls line pressure in the transmission. The EPC solenoid has a feedback circuit in the PCM that monitors EPC current. If the current indicates a short to ground (low pressure), a high side switch will be opened. This switch removes power from all 6 VFSs and the on/off shift solenoid, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position. This solenoid is tested for open (P0960), short to ground (P0962), and short to power (P0963) malfunctions.

### High Side Switch

6F35 has a high side switch that can be used to remove power from all 7 solenoids simultaneously. If the high side switch is opened, all 7 solenoids will be electrically off, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position. The switch is tested for open faults (switch failed closed will provide normal control). If the switch fails, a P0657 fault code will be stored.

ADLER (chip that controls all 7 solenoids) diagnostics:

The solenoids are controlled by an ADLER chip. The main micro sends commanded solenoid states to the ADLER, and receives back solenoid circuit fault information.

If communication with the ADLER is lost a P1636 fault code will be stored. If this failure is detected the states of the solenoids are unknown, so the control system will open the high side switch (removes power from all the solenoids), providing P, R, N and 5M with open TCC and max line pressure.

TRID Block

The TRID block is a portion of flash memory that contains solenoid characterization data tailored to the specific transmission to improve pressure accuracy.

The TRID block is monitored for two failures:

- TRID block checksum error / incorrect version of the TRID (P163E)
- TRID block not programmed (P163F)

If the TRID block is unavailable FMEM action limits operation to 1st and 3rd gear until the issue is correct.

## Transmission Control Module (TCM only present on )

The TCM has the same module diagnostics as a PCM – see miscellaneous CPU tests.

### CAN Communications Error

The TCM receives information from the ECM via the high speed CAN network. If the CAN link or network fails, the TCM no longer has torque or engine speed information available. The TCM will store a U0073 fault code and will illuminate the MIL immediately (missing engine speed) if the CAN Bus is off. The TCM will store a U0100 fault code and will illuminate the MIL immediately (missing engine speed) if it stops receiving CAN messages from the ECM. A U0401 fault codes will be stored if the ECM sends invalid/faulted information for the following CAN message items: engine torque, pedal position.

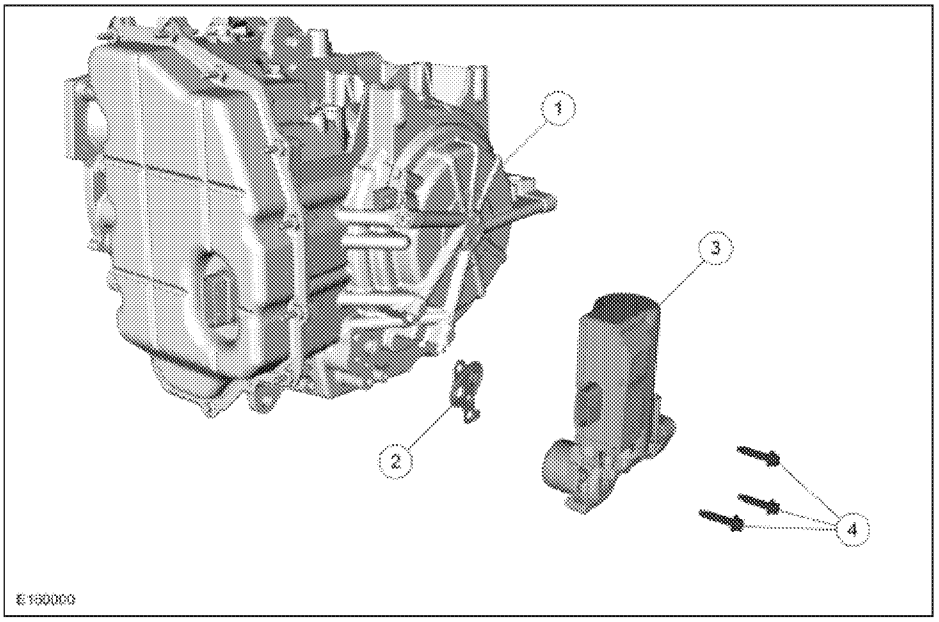
### TCM voltage

If the system voltage at the TCM is outside of the specified 9 to 16 volt range, a fault will be stored (P0882, P0883).

## Auxiliary Transmission Fluid Pump (Stop Start Applications)

For Stop Start applications, an Electronic Auxiliary Transmission Oil Pump (ePump) has been added to the transmission to allow clutches to stay engaged when the engine stops. The auxiliary pump is an electric external pump bolted to the transmission case. This allows quicker response on restarts since the transmission is ready before the main pump begins outputting pressure.

Transmission Fluid Auxiliary Pump Components




| Item | Part Number | Description |
|---|---|---|
| 1 | 7005 | Transmission case |
| 2 | 7A136 | Transmission fluid auxiliary pump-to-transmission case gasket |
| 3 | 7B086 | Transmission fluid auxiliary pump |
| 4 | W715302 | Transmission fluid auxiliary pump-to-transmission case bolt (3 required) |

The Electronic Auxiliary Transmission Oil Pump is a "smart" device – the PCM or TCM communicates with the pump via 2 Pulse Width Modulated (PWM) hardwires:

- PCM or TCM outputs a commanded pump speed to the pump using a PWM signal:

| Duty Cycle | RPM of motor |
|---|---|
| 0-9.9% | Reserved for diagnostics |
| 10-19.9 | Off state |
| 20-22.9 | 100 rpm (pre-shipment supplier test) |
| 23-90% | 937.14 rpm to 4,000 rpm (linear range of operation) |
| 90.1-100% | Reserved for diagnostics |

- The pump outputs the fault status of the pump to the PCM or TCM using a PWM signal. The fault status is used to stores the appropriate DTC in the PCM or TCM.

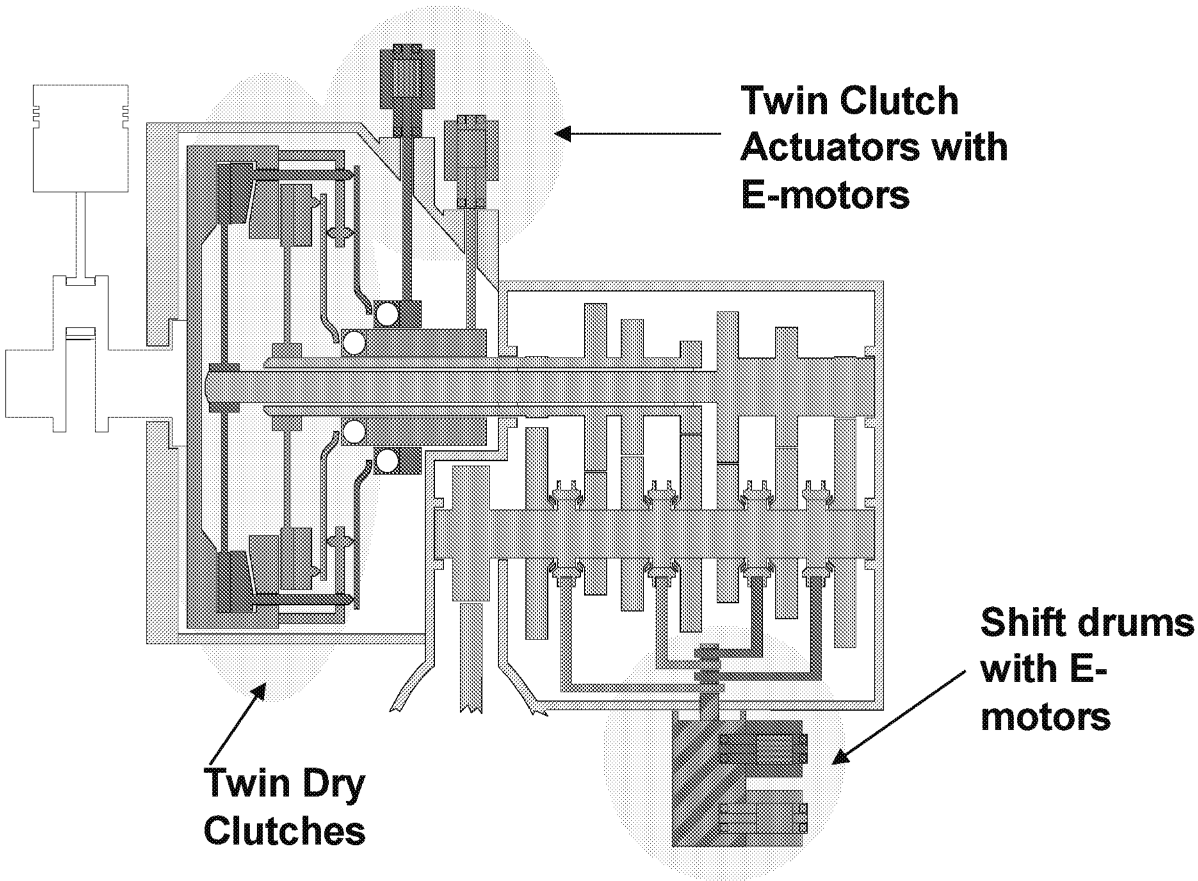
| Duty Cycle | Indicated Operating Condition | DTC | Definition |
|---|---|---|---|
| 0-10% | Out of range low | P0C2D | Electric Transmission Fluid Pump Control Module Feedback Signal Low |
| 10-15% | Under Current, Correct Speed | P0C27 | Electric/Auxiliary Transmission Fluid Pump "A" Motor Current Low |
| 20-25% | Over Current, Correct Speed | P0C28 | Electric/Auxiliary Transmission Fluid Pump "A" Motor Current High |
| 30-34% | Over Temperature | P175A | Transmission Fluid Over Temperature Condition - Electric Transmission Fluid Pump Disabled |
| 35-40% | Stalled | P0C2A | Electric/Auxiliary Transmission Fluid Pump "A" Motor Stalled |
| 45-50% | Correct Current and Speed | n/a | |
| 55-60% | Over Speed, Correct Current | P0B0D | Electric/Auxiliary Transmission Fluid Pump Motor Control Module |
| 65-70% | Under Speed, Correct Current | P0B0D | Electric/Auxiliary Transmission Fluid Pump Motor Control Module |
| 75-80% | Current and Speed out of Range | P0C29 | Electric/Auxiliary Transmission Fluid Pump "A" Driver Circuit Performance |
| 85-90% | No Command Signal Received from PCM | P2796 | Electric Transmission Fluid Pump Control Circuit |
| 90-100% | Out of range high | P0C2E | Electric Transmission Fluid Pump Control Module Feedback Signal High |
| Frequency out of range or duty cycle between valid ranges | Signal should be 120 Hz +/- 20 Hz. Should not see in-range but unused duty cycle values | P0C2C | Electric Transmission Fluid Pump Control Module Feedback Signal Range/Performance |

Failures of the pump take the Stop Start system out of operation – if stopped the engine will restart, then will no longer stop for the remainder of the current drive cycle.

## DPS6 (FWD) Transmission

DPS6 is a fully automatic 6 speed transmission made up of manual transmission gearing, combined with electro-mechanical actuators, and conventional automatic transmission controls.

### The Gearbox & Dual-Clutch System Physical Architecture




DPS6 has 2 clutches:

1. Clutch A – on in 1st, 3rd and 5th gear
2. Clutch B – on in Reverse, 2nd, 4th and 6th gear

Each clutch system consists of:

- Clutch
- 3 phase electric motor – rotates a screw driven fulcrum that controls clutch position (and torque). There are end stops at the full open and full closed positions
- Each motor phase has a hall position sensor that combine to provide a relative position – the system must sweep the clutch full open to full closed, then count increments on the sensors to know position. It takes many rotations of the motor to sweep the clutch from fully open to fully closed.
- Spring that returns the clutch to the full open position if the motor is turned off.

DPS6 has 2 shift drums:

1. Shift Drum A – controls the shift forks that engage 1st, 3rd and 5th gear
2. Shift Drum B – controls the shift forks that engage Reverse, 2nd, 4th and 6th gear

Each shift drum system consists of:

- Shift drum with groove that controls the position of shift forks
- Shift forks that engage synchronizers and gears
- 3 phase electric motor that controls the position of the shift drum
- Hall sensor system that knows the position of the motor within a rotation, used to calculate the shift drum angular position (the shift drum motor rotates 61.44 times for a single revolution of the shift drum)

Relationship between shift drum angle and gears;

| Angle | Shift drum 1 position | Shift drum 2 position |
|---|---|---|
| 0 deg | End stop near 1st | End stop near Reverse |
| 10 deg | Centered in 1st | Centered in Reverse |
| 55 deg | Neutral between 1st and 3rd | Neutral between R and 2nd |
| 90 deg | Centered in 3rd | Centered in 2nd |
| 135 deg | Neutral between 3rd and 5th | Neutral between 2nd and 4th |
| 190 deg | Centered in 5th | Centered in 4th |
| 200 deg | End stop near 5th | 4th gear |
| 235 deg | | Neutral between 4th and 6th |
| 280 | | Centered in 6th |
| 290 | | End stop near 6th |

## Transmission Inputs

Transmission Range Sensor

DPS6 is range by wire with mechanical Park. DPS6 uses a dual PWM output (at 250 Hz) TRS where one signal is the inverse of the other and the sum of the two signals add up to 100%. Each signal is tested for frequency errors (P0706 / P2801), duty cycle out of range low (P0707 / P2802) and duty cycle out of range high (P0708 / P2803). There is also a correlation error (P2805) if the two signals do not add up to 100%.

### Speed Sensors

Input 1 Speed Sensor (I1SS) – detects input shaft 1 speed, connected to clutch 1 and the odd gears (1$^{st}$, 3$^{rd}$ and 5$^{th}$). I1SS is tested for power supply faults (P06A6), circuit failures detected by the TCM hardware (P0715), erratic signal (P0716), and lack of signal (P0717).

Input 2 Speed Sensor (I2SS) – detects input shaft 2 speed, connected to clutch 2 and the even gears (R, 2$^{nd}$, 4$^{th}$ and 6$^{th}$). I2SS is tested for power supply faults (P06A7), circuit failures detected by the TCM hardware (P2765), erratic signal (P2766), and lack of signal (P2767).

Output Speed Sensor (OSS) – detects output speed. OSS is tested for power supply faults (P06A8), circuit failures detected by the TCM hardware (P0720), erratic signal (P0721), and lack of signal (P0722).

Note: because DPS6 is "Dry clutch" the only transmission fluid is for splash lube (no pump, no pressure control solenoids), so DPS6 does not have a temperature sensor.

## Transmission Outputs

DPS6 has four 3-phase electric motors:

1. Clutch A motor – controls clutch A torque capacity. The Clutch A system is tested for:
    a. ATIC faults (P0805) – the ATIC is an internal TCM component that controls motor current.
    b. Hall sensor faults (P0806) – each phase has a hall sensor that provides motor position information
    c. Sequence faults (P0809) – as the motor rotates it generates an defined pattern from the 3 hall sensors, if the sequence of hall sensor patterns is off this code sets.
    d. Open circuit (P0900)
    e. Short to ground (P0902)
    f. Short to power (P0903)
    g. Clutch functionally stuck off (P07A2)
    h. Clutch functionally stuck on (P07A3)

2. Clutch B motor – controls clutch B torque capacity. The Clutch B system is tested for:
    a. ATIC faults (P087A) – the ATIC is an internal TCM component that controls motor current.
    b. Hall sensor faults (P087B) – each phase has a hall sensor that provides motor position information
    c. Sequence faults (P087E) – as the motor rotates it generates an defined pattern from the 3 hall sensors, if the sequence of hall sensor patterns is off this code sets.
    d. Open circuit (P090A)
    e. Short to ground (P090C)
    f. Short to power (P090D)
    g. Clutch functionally stuck off (P07A4)
    h. Clutch functionally stuck on (P07A5)

3. Shift drum A motor – controls the shift forks that engage 1st, 3rd and 5th gear. The system is tested for:
    a. ATIC faults (P2831) – the ATIC is an internal TCM component that controls motor current.
    b. Sequence faults (P2835) – as the motor rotates it generates an defined pattern from the 3 hall sensors, if the sequence of hall sensor patterns is off this code sets.
    c. Open circuit (P285B)
    d. Short to ground (P285D)
    e. Short to power (P285E)
    f. Stuck in gear (P072C, P072E, P073A)
    g. Position error (P2832) – includes blocked motor, or any failure that results in the TCM losing confidence in the relative position of the shift drum.

4. Shift drum A motor – controls the shift forks that engage 1st, 3rd and 5th gear. The system is tested for:
    a. ATIC faults (P2836) – the ATIC is an internal TCM component that controls motor current.
    b. Sequence faults (P283A) – as the motor rotates it generates an defined pattern from the 3 hall sensors, if the sequence of hall sensor patterns is off this code sets.
    c. Open circuit (P285F)
    d. Short to ground (P2861)
    e. Short to power (P2862)
    f. Stuck in gear (P072B, P072D, P072F, P073B)
    g. Position error (P2837) – includes blocked motor, or any failure that results in the TCM losing confidence in the relative position of the shift drum.

## Transmission Control Module (TCM)

The TCM monitors itself by using various software monitoring functions. The TCM is monitored for:

a. If a RAM Read/Write error is detected during initialization, a P0604 fault code will be stored

b. the flash ROM is checked using a checksum calculation. If the checksum is incorrect during a P0605 fault will be stored

c. CPU performance is monitored for incorrect instructions or resets, if detected a P0607 fault code is set

d. If an error is found with NVRAM a P06B8 fault code will be stored

### CAN Communications error

The TCM receives information from the ECM via CAN. If the CAN link fails the TCM no longer has torque or engine speed information available. The TCM will store a U0073 fault code if the CAN Bus is off. The TCM will store a U0100 fault code if it doesn't receive any more CAN messages from the ECM. A U0401 fault codes will be stored if the ECM received invalid/faulted information for the following CAN message items: engine torque, pedal position.

System voltage:

the TCM monitors system voltage and stores fault codes if it is out of range low (P0882) or out of range high (P0883). These thresholds are set based on hardware capability.

[redacted]

# 6R140 (RWD) Transmission with PCM or external TCM

## Transmission Control System Architecture

Starting in 2011 MY 6R140 replaces 5R110W in Super Duty truck applications.

The 6R140 is a 6-speed, step ratio transmission that is controlled by an external PCM (gas engine applications) or TCM (Diesel engine applications). For Diesel the TCM communicates to the Engine Control Module (ECM), ABS Module, Instrument Cluster and Transfer Case Control Module using the high speed CAN communication link. The TCM incorporates a standalone OBD-II system. The TCM independently processes and stores fault codes, freeze frame, supports industry-standard PIDs as well as J1979 Mode 09 CALID and CVN. The TCM does not directly illuminate the MIL, but requests the ECM to do so. The TCM is located outside the transmission assembly. It is not serviceable with the exception of reprogramming.

## Transmission Inputs

Transmission Range Sensor

6R140 uses a Non-contacting Pulse Width Modulated Transmission Range Sensor (TRS) that provides a duty cycle signal for each position. This signal is transmitted at a frequency of 125 Hz. The PCM / TCM decode the duty cycle to determine the driver-selected gear position (Park, Rev, Neutral, OD, 3, 2, 1). This input device is checked for frequency out of range (P0706), duty cycle out of range low (P0707) and duty cycle out of range high (P0708)

### Speed Sensors

The Turbine Shaft Speed (TSS) sensor and Output Shaft Speed (OSS) sensor are Hall effect sensors.

The Turbine Shaft Speed sensor is monitored by a rationality test, if engine speed and output shaft speed are high and a gear is engaged, it can be inferred that the vehicle is moving. If there is insufficient output from the TSS sensor a fault is stored (P0715).

The Output Shaft Speed sensor is monitored by a rationality test. If engine speed and turbine speed are high and a gear is engaged, it can be inferred that the vehicle is moving. If there is insufficient output from the OSS sensor a fault is stored (P0720).

### Transmission Fluid Temperature

The Transmission Fluid Temperature Sensor is checked for out of range low (P0712), out of range high (P0713), and in-range failures (P0711).

## Transmission Outputs

### Shift Solenoids

6R140 has 5 shift solenoids:

- SSA – a Variable Force Solenoid (VFS) that controls CB1234 (a brake clutch, grounds an element to the case, that is on in 1st, 2nd, 3rd and 4th gear)
- SSB – a VFS that controls C35R (a rotating clutch on in 3rd, 5th and Reverse)
- SSC – a VFS that controls CB26 (a brake clutch on in 2nd and 6th gear)
- SSD – a VFS that controls CBLR (a brake clutch on in 1st gear with engine braking and Reverse)
- SSE – a VFS that controls C456 (a rotating clutch on in 4th, 5th and 6th gear)

Output circuits are checked for opens, short to ground and short to power faults (codes listed in that order) by the "smart driver" (see ADLER below) that controls the solenoids (SSA P0750, P0973, P0974; SSB P0755, P0976, P0977; SSC P0760, P0979, P0980; SSD P0765, P0982, P0983; SSE P0770, P0985, P0986).

The shift solenoids are also functional tested for stuck on and stuck off failures. This is determined by vehicle inputs such as gear command, and achieved gear (based on turbine and output speed). In general the shift solenoid malfunction codes actually cover the entire clutch system (solenoid, valves, seals and the clutch itself since using ratio there is no way to isolate the solenoid from the rest of the clutch system)

For SSA thru SSE Diagnostics will isolate the fault into clutch functionally (non-electrical) failed off (SSA P0751, SSB P0756, SSC P0761, SSD P0766. SSE P0771) and clutch functionally failed on (SSA: P0752, SSB: P0757, SSC: P0762, SSD: P0767, SSE: P0772).

### Gear ratio errors:

If ratio errors are detected that do not match an expected pattern for a failed solenoid then gear ratio error fault codes (1st gear – P0731, 2nd gear – P0732, 3rd gear – P0733, 4th gear – P0734, 5th gear – P0735 or 6th gear – P0729) will be stored.

### Torque Converter Clutch

The Torque Converter Clutch (TCC) solenoid is a Variable Force Solenoid. TCC solenoid circuit is checked electrically for open, short to ground and short to power circuit faults internally by the "smart driver" that controls the solenoids (P0740, P0742, P0744).

The TCC solenoid is checked functionally for stuck off faults by evaluating torque converter slip under steady state conditions when the torque converter is fully applied. If the slip exceeds the malfunction thresholds when the TCC is commanded on, a TCC malfunction is indicated (P0741).

The TCC solenoid is monitored functionally for stuck on faults (P2758) by monitoring for lack of clutch slip when the TCC is commanded off, but this code is non-MIL because while a stuck on TCC solenoid may cause driveability complaints and/or cause engine stalls it does not impact emissions or fuel economy.

### Electronic Pressure Control

The EPC solenoid is a variable force solenoid that controls line pressure in the transmission. The EPC solenoid is monitored for open, short to ground or short to power faults by the "smart driver" that controls the solenoid. If a short to ground (low pressure) is detected, a high side switch will be opened. This switch removes power from all 7 VFSs, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position. This solenoid is tested for open (P0960), short to ground (P0962), and short to power (P0963) malfunctions.

### Transmission Solenoid Power Controll (TSPC)

6F140 PCM or TCM has a internal high side switch called TSPC that can be used to remove power from all 7 solenoids simultaneously. If the high side switch is opened, all 7 solenoids will be electrically off, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position.

Due to current limitations TSPC is split into 2 pins / wires at the PCM / TCM. TSPC A provides power to SSA, SSC and SSE. TSPC B provides power to SSB, SSD, TCC and LPC. Each wire can be tested independently; P0657 sets for an issue with TSPC-A, P2669 sets for an issue with TPSC-B.

Although there are 2 pins and wires between the PCM / TCM and the transmission bulkhead connector the PCM / TCM contains only one TSPC internally – so the FMEM for either wire being failed is to open TSCP inside the PCM / TCM, which removes power from all 7 solenoids, providing P, R, N and 5$^{th}$ gear with open TCC and max line as FMEM for any TPSC faults.

ADLER (chip that controls all 7 solenoids) diagnostics:

The solenoids are controlled by an ADLER chip. The main micro sends commanded solenoid states to the ADLER, and receives back solenoid circuit fault information.

If communication with the ADLER is lost a P1636 fault code will be stored. If this failure is detected the states of the solenoids are unknown, so the control system will open the high side switch (removes power from all the solenoids), providing P, R, N and 5M with open TCC and max line pressure.

TRID Block

The TRID block is a portion of flash memory that contains solenoid characterization data tailored to the specific transmission to improve pressure accuracy.

The TRID block is monitored for two failures:

- TRID block checksum error / incorrect version of the TRID (P163E)
- TRID block not programmed (P163F)

If the TRID block is unavailable FMEM action limits operation to 1$^{st}$ and 3$^{rd}$ gear until the issue is correct.

## Transmission Control Module (TCM – Diesel only)

The TCM has the same module diagnostics as a PCM – see miscellaneous CPU tests.

### CAN Communications Error

The TCM receives information from the ECM via the high speed CAN network. If the CAN link or network fails, the TCM no longer has torque or engine speed information available. The TCM will store a U0073 fault code and will illuminate the MIL immediately (missing engine speed) if the CAN Bus is off. The TCM will store a U0100 fault code and will illuminate the MIL immediately (missing engine speed) if it stops receiving CAN messages from the ECM. A U0401 fault codes will be stored if the ECM sends invalid/faulted information for the following CAN message items: engine torque, pedal position.

### TCM voltage

If the system voltage at the TCM is outside of the specified 9 to 16 volt range, a fault will be stored (P0882, P0883).

## On Board Diagnostic Executive

The On-Board Diagnostic (OBD) Executive is a portion of the PCM strategy that manages the diagnostic trouble codes and operating modes for all diagnostic tests. It is the "traffic cop" of the diagnostic system. The Diagnostic Executive performs the following functions:

- Sequence the OBD monitors such that when a test runs, each input that it relies upon has already been tested. For 2008 MY and beyond ISO 14229 programs, the OBD monitors are no longer sequenced by the diagnostic executive.
- Controls and co-ordinates the execution of the individual OBD system monitors: Catalyst, Misfire, EGR, O2, Fuel, AIR, EVAP and, Comprehensive Component Monitor (CCM). For 2008 MY and beyond ISO 14229 programs, the execution of the OBD monitors is no longer controlled and coordinated by the diagnostic executive.
- Stores freeze frame and "similar condition" data.
- Manages storage and erasure of Diagnostic Trouble Codes as well as MIL illumination.
- Controls and co-ordinates the execution of the On-Demand tests: Key On Engine Off (KOEO)Key On Engine Running (KOER), and the Output Test Mode (OTM). For 2008 MY and beyond ISO 14229 programs, the Output Test Mode is no longer supported by the diagnostic executive.
- Performs transitions between various states of the diagnostic and powertrain control system to minimize the effects on vehicle operation.
- Interfaces with the diagnostic test tools to provide diagnostic information (I/M readiness, various J1979 test modes) and responses to special diagnostic requests (J1979 Mode 08 and 09).
- Tracks and manages indication of the driving cycle which includes the time between two key on events that include an engine start and key off.

The diagnostic executive also controls several overall, global OBD entry conditions.

- The battery voltage must fall between 11.0 and 18.0 volts to initiate monitoring cycles.
- The engine must be started to initiate the engine started, engine running, and engine off monitoring cycles.
- The Diagnostic Executive suspends OBD monitoring when battery voltage falls below 11.0 volts.
- The Diagnostic Executive suspends monitoring of fuel-system related monitors (catalyst, misfire, evap, O2, AIR and fuel system) when fuel level falls below 15%. For 2005 MY and beyond, the execution of the fuel related OBD monitors is no longer suspended for fuel level by the diagnostic executive.

The diagnostic executive controls the setting and clearing of pending and confirmed DTCs.

- A pending DTC and freeze frame data is stored after a fault is confirmed on the first monitoring cycle. If the fault recurs on the next driving cycle, a confirmed DTC is stored, freeze frame data is updated, and the MIL is illuminated. If confirmed fault free on the next driving cycle, the pending DTC and freeze frame data is erased on the next power-up.
- For the 2005 MY and later, pending DTCs will be displayed as long as the fault is present. Note that OBD-II regulations required a complete fault-free monitoring cycle to occur before erasing a pending DTC. In practice, this means that a pending DTC is erased on the next power-up after a fault-free monitoring cycle.
- For clearing comprehensive component monitoring (CCM) pending DTCs, the specific monitor must determine that no fault is present, and a 2-hour engine off soak has occurred prior to starting the vehicle. The 2-hour soak criteria for clearing CCM confirmed and pending DTCs has been utilized since the 2000 MY. For 2008 MY and beyond ISO 14229 programs, the engine off soak is no longer used by the diagnostic executive.
- After a confirmed DTC is stored and the MIL has been illuminated, three consecutive confirmed fault-free monitoring cycles must occur before the MIL can be extinguished on the next (fourth) power-up. After 40 engine warm-ups, the DTC and freeze frame data is erased.

The diagnostic executive controls the setting and clearing of permanent DTCs.

- A permanent DTC is stored when a confirmed DTC is stored, the MIL has been illuminated, and there are not yet six permanent DTCs stored.
- After a permanent DTC is stored, three consecutive confirmed fault-free monitoring cycles must occur before the permanent DTC can be erased.
- After a permanent DTC is stored, one confirmed fault-free monitoring cycle must occur, following a DTC reset request, before the permanent DTC can be erased. For 2010MY and beyond ISO 14229 programs a driving cycle including the following criteria must also occur, following the DTC reset request, before a permanent DTC can be erased:
    - Cumulative time since engine start is greater than or equal to 600 seconds;
    - Cumulative vehicle operation at or above 25 miles per hour occurs for greater than or equal to 300 seconds (medium-duty vehicles with diesel engines certified on an engine dynamometer may use cumulative operation at or above 15% calculated load in lieu of at or above 25 miles per hour for purposes of this criteria); and
    - Continuous vehicle operation at idle (i.e., accelerator pedal released by driver and vehicle speed less than or equal to one mile per hour) for greater than or equal to 30 seconds.
- A permanent DTC can not be erased by a KAM clear (battery disconnect). Additionally, its confirmed DTC counterpart will be restored after completion of the KAM reset (battery reconnect).

## Exponentially Weighted Moving Average

Exponentially Weighted Moving Averaging is a well-documented statistical data processing technique that is used to reduce the variability on an incoming stream of data. Use of EWMA does not affect the mean of the data; however, it does affect the distribution of the data. Use of EWMA serves to "filter out" data points that exhibit excessive and unusual variability and could otherwise erroneously light the MIL.

The simplified mathematical equation for EWMA implemented in software is as follows:

New Average = [New data point * "filter constant"] + [( 1 - "filter constant" ) * Old Average]

This equation produces an exponential response to a step-change in the input data. The "Filter Constant" determines the time constant of the response. A large filter constant (i.e. 0.90) means that 90% of the new data point is averaged in with 10% of the old average. This produces a very fast response to a step change. Conversely, a small filter constant (i.e. 0.10) means that only 10% of the new data point is averaged in with 90% of the old average. This produces a slower response to a step change.

When EWMA is applied to a monitor, the new data point is the result from the latest monitor evaluation. A new average is calculated each time the monitor is evaluated and stored in Keep Alive Memory (KAM). This normally occurs each driving cycle. The MIL is illuminated and a DTC is stored based on the New Average store in KAM.

In order to facilitate repair verification and DDV demonstration, 2 different filter constants are used. A "fast filter constant" is used after KAM is cleared or DTCs are erased and a "normal filter constant" is used for normal customer driving. The "fast filter" is used for 2 driving cycles after KAM is cleared/DTCs are erased, and then the "normal filter" is used. The "fast filter" allows for easy repair verification and monitor demonstration in 2 driving cycles, while the normal filter is used to allow up to 6 driving cycles, on average, to properly identify a malfunction and illuminate the MIL. This feature is called Fast Initial Response (FIR). The fast filter is always calibrated to 1.0 which means that the EWMA is effectively disabled because the new average is 100% of the new data point. Since the EWMA is effectively disabled, it takes twp driving cycles to set the MIL. The first driving cycle with a fault will set a pending DTC; the second driving cycle will set a confirmed code and illuminate the MIL.

The other unique feature used with EWMA is called Step Change Logic (SCL). This logic detects an abrupt change from a no-fault condition to a fault condition. This is done by comparing the new data point to the EWMA old average. If the two points differ by more than a calibrated amount (i.e. the new data point is outside the normal distribution), it means that a catastrophic failure has occurred. The fast filter is then used in the same manner as for the FIR feature above. Since the EWMA is effectively disabled, it takes twp driving cycles to set the MIL. The first driving cycle with a fault will set a pending DTC; the second driving cycle will set a confirmed code and illuminate the MIL. The SCL becomes active after the 4th "normal" monitoring cycle to give the EWMA a chance to stabilize.

During "normal" EWMA operation, a slower filter constant is used. The "normal filer" allows the MIL to be illuminated in 1 to 6 driving cycles. A confirmed code is set and the MIL is illuminated as soon as the EWMA crosses the malfunction threshold. There is no pending DTC because EWMA uses a 1-trip MIL.

In order to relate filter constants to driving cycles for MIL illumination, filter constants must be converted to time constants. The mathematical relationship is described below:

Time constant = [ ( 1 / filter constant ) - 1 ] * evaluation period

The evaluation period is a driving cycle. The time constant is the time it takes to achieve 68% of a step-change to an input. Two time constants achieve 95% of a step change input.

## EWMA Examples

EWMA with FIR and SCL has been incorporated in the IAF catalyst monitor, the Rear O2 response test and the EONV Evaporative system leak check monitor. There are 3 parameters that determine the MIL illumination characteristics.

"Fast" filter constant (0.9999), used for 2 driving cycles after DTCs are cleared/KAM is reset (FIR) and for Step Change Logic (SCL)

"Normal" filter constant( typically 0.4), used for all subsequent, "normal" customer driving

Number of driving cycles to use fast filter after KAM clear (set to 2 driving cycles)

Several examples for a typical catalyst monitor calibration are shown in the tables below. The first example does not show SCL in order to better illustrate the EWMA calculation and the 1-trip MIL.

| Monitor evaluation ("new data") | EWMA Filter Calculation, "normal" filter constant set to 0.4 Malfunction threshold = .75 | Weighted Average ("new average") | Driving cycle number | Action/Comment |
|---|---|---|---|---|
| 0.15 | .15 * (0.4) + .15 * ( 1 - 0.4) | 0.15 | | normal 120K system |
| 1.0 | 1.0 * (0.4) + .15 * ( 1 - 0.4) | 0.49 | 1 | large failure occurs |
| 1.0 | 1.0 * (0.4) + .49 * ( 1 - 0.4) | 0.69 | 2 | |
| 1.0 | 1.0 * (0.4) + .69 * ( 1 - 0.4) | 0.82 | 3 | exceeds threshold, MIL on |
| 1.0 | 1.0 * (0.4) + .82 * ( 1 - 0.4) | 0.89 | 4 | MIL on |
| | | | | |
| 0.8 | 0.8 * (0.4) + .15 * ( 1 - 0.4) | 0.41 | 1 | 1.5 * threshold failure |
| 0.8 | 0.8 * (0.4) + .41 * ( 1 - 0.4) | 0.57 | 2 | |
| 0.8 | 0.8 * (0.4) + .57 * ( 1 - 0.4) | 0.66 | 3 | |
| 0.8 | 0.8 * (0.4) + .66 * ( 1 - 0.4) | 0.72 | 4 | |
| 0.8 | 0.8 * (0.4) + .72 * ( 1 - 0.4) | 0.75 | 5 | equals threshold, MIL on |
| 0.8 | 0.8 * (0.4) + .75 * ( 1 - 0.4) | 0.77 | 6 | MIL on |
| | | | | |
| 0.8 | 0.8 * (0.99) + 0* ( 1 - 0.99) | 0.8 | 1 | 1.5 * threshold failure after code clear, pending DTC |
| 0.8 | 0.8 * (0.99) + .8 * ( 1 - 0.99) | 0.8 | 2 | MIL on (I/M Readiness set to "ready" |

Note that older implementations of EWMA for the Index ratio catalyst monitor and non-intrusive stepper motor EGR monitor incorporate Fast Initial Response but do not incorporate step change logic. For both FIR and normal EWMA usage, a pending code is set when the new EWMA average exceeds the threshold and a confirmed code is set after the second time the EWMA average exceeds the threshold. (2-trip MIL). The "normal" filter is calibrated to illuminate the MIL between 2 and 6 driving cycles.

## I/M Readiness

The readiness function is implemented based on the SAE J1979/ISO 15031-5 format. Clearing codes using a scan tool results in the various I/M readiness bits being set to a “not-ready” condition. As each non-continuous monitor completes a full diagnostic check, the I/M readiness bit associated with that monitor is set to a “ready” condition. This may take one or two driving cycles based on whether malfunctions are detected or not. The readiness bits for comprehensive component monitoring and misfire monitoring are immediately considered complete since they are continuous monitors. Because the evaporative system monitor requires ambient conditions between 40 and 100 $^{o}$F and BARO > 22.5 " Hg (< 8,000 ft.) to run, special logic can “bypass” the running the evap monitor for purposes of clearing the evap system I/M readiness bit due to the continued presence of these extreme conditions. The table below shows which monitors must complete for I/M readiness.

| I/M Readiness bit | Bank 1 | Bank 2 |
|---|---|---|
| Catalyst monitoring | P0420 | P0430 |
| Heated catalyst monitoring | Not Supported | Not Supported |
| Evaporative system monitoring (0.040"/0.150" monitor used for I/M readiness) | P0442 (0.040")<br>P0455 (0.150 for HD OBD) | |
| Secondary air system monitoring | P0491/P0410/P2448 | P0492/P2449 |
| Oxygen sensor monitoring | | |
| Upstream response test | P0133 | P0153 |
| Upstream lack of movement test | P2195/P2196 | P2197/P2198 |
| Upstream heater | P0053/P0030 | P0059/P0050 |
| Downstream functional test | P0136/P2270/P2271 | P0156/P2272/P2273 |
| Downstream heater | P0054/P00D2 | P0060P00D4 |
| Downstream response test | P013A/P013E | P013C/P014A |
| Post catalyst fuel trim monitor | P2096/P0297 | P2098/P2099 |
| Oxygen sensor heater monitoring | Same as O2 sensor above | Same as O2 sensor above |
| EGR and/or VVT system monitoring | | |
| Stepper Motor EGR<br>DPFE EGR | P0400<br>P1405/P1406/P0401/P0402 | |
| VVT supported | P0011/P0012/P0014/P0015 | P0021/P0022/P0024/P0025 |
| Misfire monitoring | Always ready | Always ready |
| Fuel system monitoring | Fuel trim always ready | Fuel trim always ready |
| A/F ratio imbalance monitor | P219A | P219B |
| Comprehensive component monitoring | Always ready | Always ready |

## Evap bypass logic for new 1999 MY, 2000 MY, and beyond vehicles:

If the evaporative system monitor conditions are met with the exception of the 40 to 100 $^{o}$F ambient temperatures or BARO range, a timer is incremented. The timer value is representative of conditions where the Evap monitor could have run (all entry conditions met except IAT and BARO) but did not run due to the presence of those extreme conditions. If the timer continuously exceeds 30 seconds during a driving cycle in which all continuous and non-continuous monitors were evaluated, the evaporative system monitor is then considered complete. If the above conditions are repeated during a second driving cycle, the I/M readiness bit for the evaporative system is set to a "ready" condition.

## Power Take Off Mode

While PTO mode is engaged, the I/M readiness bits are set to a "not-ready" condition. When PTO mode is disengaged, the I/M readiness bits are restored to their previous states prior to PTO engagement. During PTO mode, only CCM circuit checks continue to be performed.

## In-Use Monitor Performance Ratio

Manufacturers are required to implement software algorithms that track in-use performance for each of the following components: catalyst bank 1, catalyst bank 2, primary oxygen sensor bank 1, primary oxygen sensor bank 2, evaporative 0.020" leak detection system, EGR system, and secondary air system, and secondary oxygen sensor bank 1 and secondary oxygen sensor bank 2 for 2010 MY and beyond. The numerator for each component or system tracks the number of times that all conditions necessary for a specific monitor to detect a malfunction have been encountered. The denominator for each component or system tracks the number of times that the vehicle has been operated in the specified conditions.

If a vehicle utilizes Variable Valve Timing (VVT) in place of EGR, the VVT in-use data is reported in place of the EGR in-use data. If a vehicle utilizes both an EGR system and a VVT system, the PCM tracks the in-use performance data for both monitors, but reports only the data for the system with the lowest numerical ratio.

If a vehicle utilizes an evaporative system monitor that is certified to 0.040" or 0.150" requirements instead of 0.020" requirements, the PCM reports the 0.040" monitor or 0.150" monitor in-use performance data in place of the 0.020" in-use performance data.

The table below shows which monitors must complete to increment each IUMPR numerator.

Note that EVAP monitor takes longer to find a fault than to pass, therefore, it must use a "ghost monitor" that tracks whether the monitor could have found a fault, had a fault been present. To increment the IUMPR counter for EVAP, the 0.020" leak check must maintain monitoring conditions for 45 minutes after shutdown. The 0.040" leak check must maintain monitoring condition based on the longest time it take to pull to target vacuum. If the actual monitor fails, the ghost monitor does not run and the numerator is incremented.

Note that Catalyst monitor uses EWMA. The numerator increments after the catalyst monitor completes. After a code clear, the numerator increments after catalyst monitor completes 6 times.

| IUMPR Counter Numerator | Controling Monitor |
|---|---|
| Catalyst Monitoring Bank 1 | P0420 |
| Catalyst Monitoring Bank 12 | P0430 |
| O2 Sensor Monitoring Bank 1 | P0133 |
| O2 Sensor Monitoring Bank 2 | P0153 |
| EGR and/or VVT System Monitoring | |
| EGR (if supported) | P0400/P0401 |
| VVT (if supported) | P0011/P0012/P0014/P0015<br>P0021/P0022/P0024/P0025 |
| EVAP Monitoring | |
| 0.020" monitoring (California) | P0456 |
| 0.040" monitoring (Federal) | P0442 |
| 0.150" monitoring (HD OBD) | P0455 |
| AIR Monitoring | P0410/P0491/P2448 |
| Secondary O2 Sensor Monitoring Bank 1 | P013A/P013E |
| Secondary O2 Sensor Monitoring Bank 2 | P013C/P014A |

## Catalyst Temperature Model

A catalyst temperature model is currently used for entry into the catalyst and oxygen sensor monitors. The catalyst temperature model uses various PCM parameters to infer exhaust/catalyst temperature. For the 1998 MY, the catalyst temperature model has been enhanced and incorporated into the Type A misfire monitoring logic. The model has been enhanced to include a misfire-induced exotherm prediction. This allows the model to predict catalyst temperature in the presence of misfire.

The catalyst damage misfire logic (Type A) for MIL illumination has been modified to require that both the catalyst damage misfire rate and the catalyst damage temperature is being exceeded prior to MIL illumination. This change is intended to prevent the detection of unserviceable, unrepeatable, burst misfire during cold engine start-up while ensuring that the MIL is properly illuminated for misfires that truly damage the catalyst.

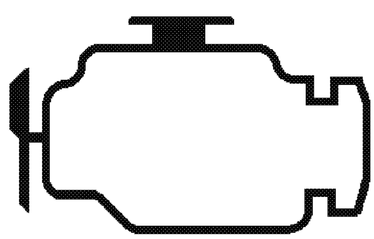
Beginning with the 2007 MY, the catalyst temperature model is also used to generate the primary inputs to the CSER Monitor as described in that section of this document.

## Serial Data Link MIL Illumination

The OBD-II diagnostic communication messages utilize an industry standard 500 kbps CAN communication link.

The instrument cluster on some vehicles uses the same CAN data link to receive and display various types of information from the PCM. For example, the engine coolant temperature information displayed on the instrument cluster comes from the same ECT sensor used by the PCM for all its internal calculations.

These same vehicles use the CAN data link to illuminate the MIL rather than a circuit, hard-wired to the PCM. The PCM periodically sends the instrument cluster a message that tells it to turn on the MIL, turn off the MIL or blink the MIL. If the instrument cluster fails to receive a message within a 5-second timeout period, the instrument cluster itself illuminates the MIL. If communication is restored, the instrument cluster turns off the MIL after 5 seconds. Due to its limited capabilities, the instrument cluster does not generate or store Diagnostic Trouble Codes.

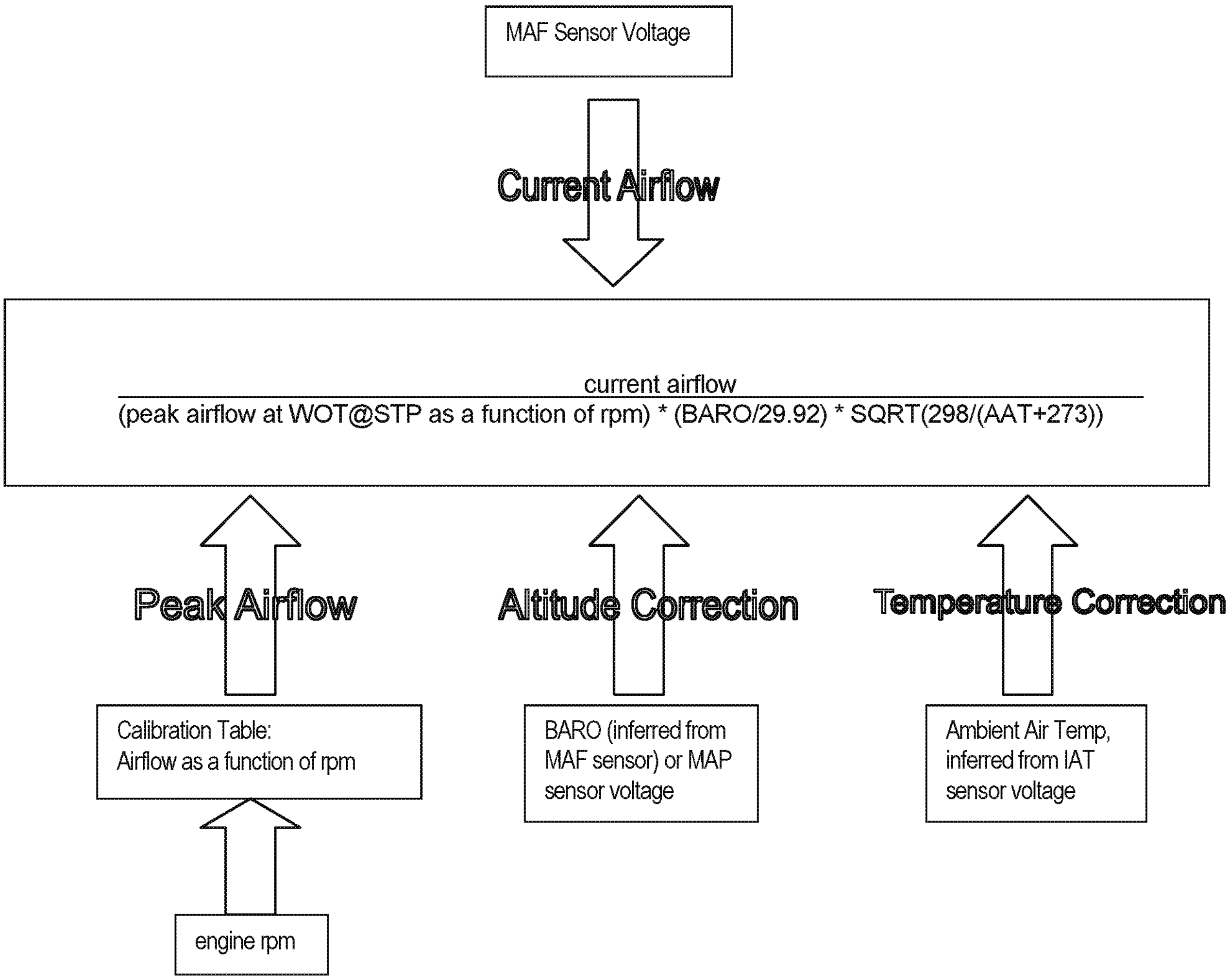


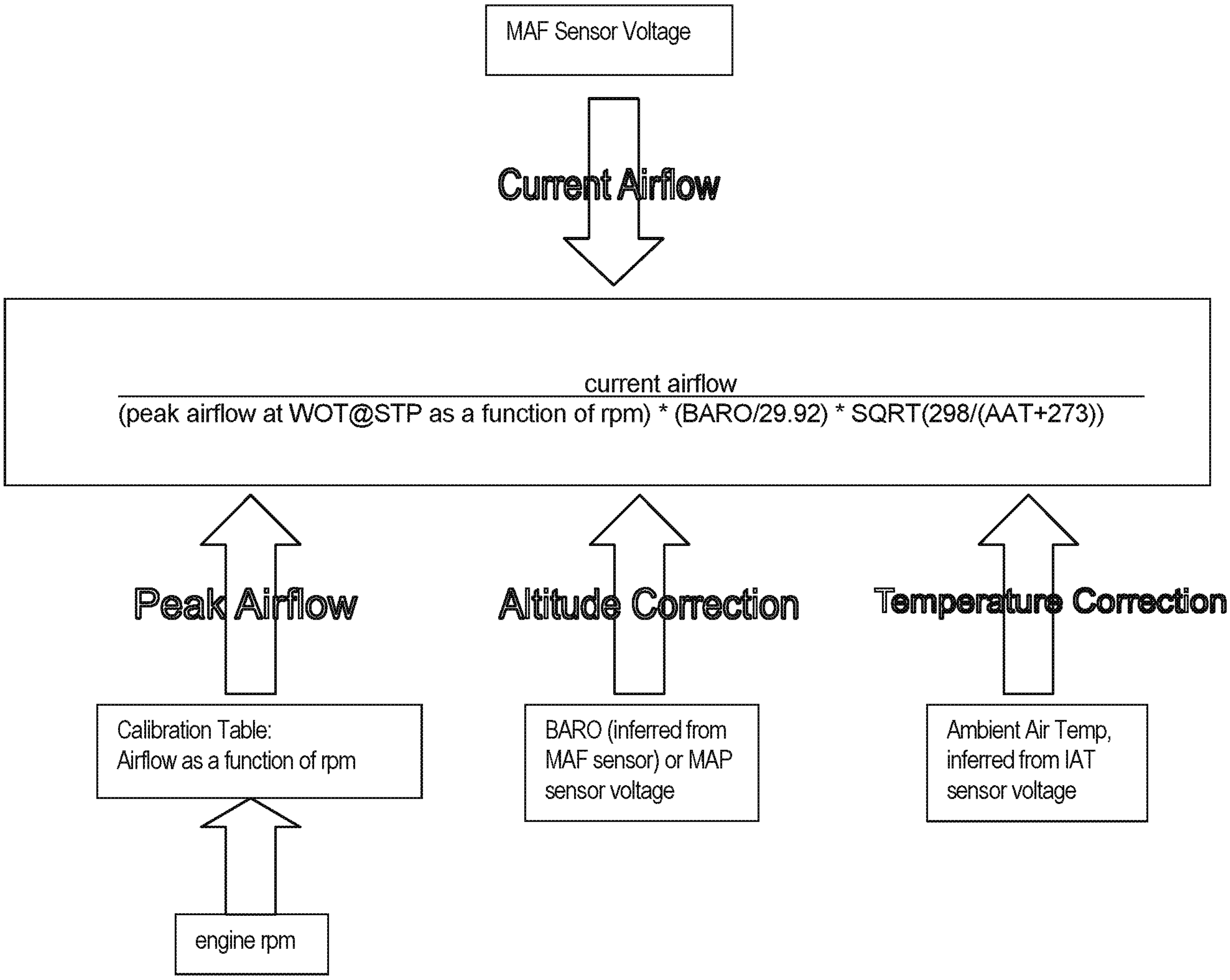
# Calculated Load Value

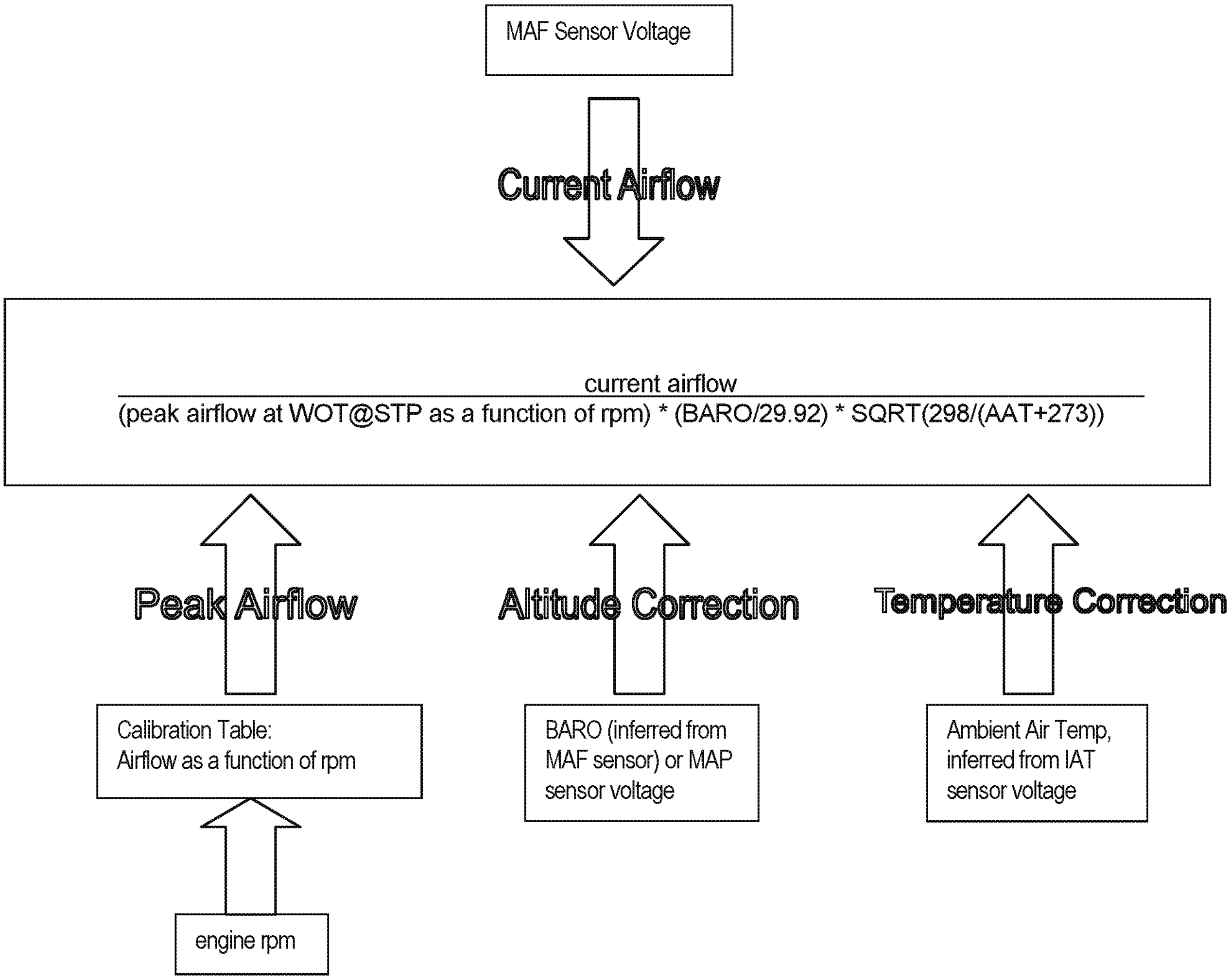
LOAD_PCT (PID $04) =

$$\frac{\text{current airflow}}{(\text{peak airflow at WOT@STP as a function of rpm}) * (\text{BARO}/29.92) * \text{SQRT}(298/(\text{AAT}+273))}$$

Where: STP = Standard Temperature and Pressure = 25 $^{o}$C, 29.92 in Hg BARO,
SQRT = square root,
WOT = wide open throttle,
AAT = Ambient Air Temperature and is in $^{o}$C




MAF Sensor Voltage
Current Airflow
current airflow
(peak airflow at WOT@STP as a function of rpm) * (BARO/29.92) * SQRT(298/(AAT+273))
Peak Airflow
Altitude Correction
Temperature Correction
Calibration Table:
Airflow as a function of rpm
BARO (inferred from MAF sensor) or MAP sensor voltage
Ambient Air Temp, inferred from IAT sensor voltage
engine rpm


MAF Sensor Voltage
Current Airflow
current airflow
(peak airflow at WOT@STP as a function of rpm) * (BARO/29.92) * SQRT(298/(AAT+273))
Peak Airflow
Altitude Correction
Temperature Correction
Calibration Table:
Airflow as a function of rpm
BARO (inferred from MAF sensor) or MAP sensor voltage
Ambient Air Temp, inferred from IAT sensor voltage
engine rpm

# Preliminary 2013 MY OBD System Operation Summary for Plug In and Hybrid Electric Vehicles

Table of Contents

## HEV Powertrain Description

A hybrid electric vehicle is powered by a conventional engine with an electric motor added for enhanced fuel economy and reduced emissions. The electric motor can also be used to boost power and enhance performance (like an extra "charge"). This type of vehicle is well suited for the environmentally aware driver who wants better fuel economy and fewer pollutants, but doesn't want the hassle of plug-ins.

A vehicle can be "more" of a hybrid than another. There are various levels of "hybridization," mild, full, and plug-in.

With all HEV variants, the engine turns off when it is not needed, reducing fuel waste, and instantly restarts when the need for power is detected. In addition, all hybrids provide electric assist, in that the combustion engine gets a boost of electric power from the battery pack. This provides additional acceleration performance when needed, without additional use of fuel. The main difference between the HEV variants is in the relative sizing of the electric powertrain to the combustion powertrain.

A mild hybrid has a relatively small electric motor to provide traction power and a small capacity battery. It is designed to provide a start-stop function along with a small amount of acceleration power (used to assist the combustion engine) and a small amount of regenerative braking (meaning vehicle energy that would otherwise would be wasted, is collected during braking to recharge the battery).

A full hybrid provides the same functions as a mild hybrid, but to a larger degree. Since it uses a larger electric motor and battery, it can provide greater amount of acceleration and regenerative braking power. In addition, a full hybrid provides an electric launch, whereby the electric motor can accelerate the vehicle without the combustion engine for small distances. The electric motor can be used to accelerate by itself (in pure electric mode) or in combination with the internal combustion engine (for greater power).

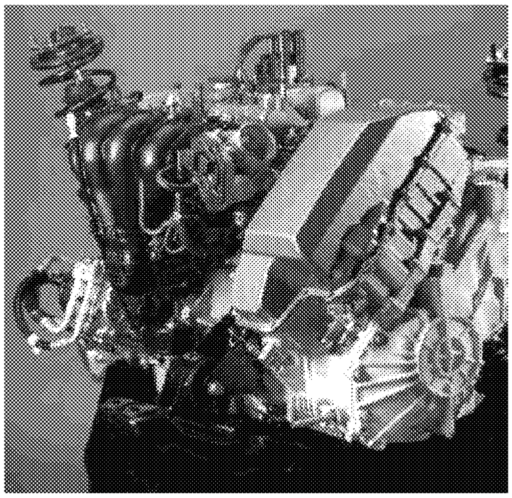
Plug-In hybrids have all of the functions and capabilities of a full hybrid, however, they use a larger battery which gives them greater electric-only driving range. In addition, plug-in hybrids have a charge port which can be used to charge the battery externally from electric mains to allow them to have full electric range without having to run the combustion engine.

## Benefits of Hybrid Electric Vehicles

- Reduces emissions by increasing average engine efficiency.
- Engine shuts down, when the vehicle is stopped.
- Electric motor boosts acceleration performance.
- Regenerative brakes recapture energy, to recharge the battery.
- Improved fuel economy stretches a tank of gas further, saves you money, and helps you conserve our limited petroleum resources.
- Driving performance is optimized because both the gas engine and electric motor are working for you.
- No battery plug-ins required for mild and full hybrids, and optional for plug-in hybrid.
- An HEV offers all the conveniences of conventional vehicles: spacious seating, storage room, creature comforts, and extended driving range.
- All Ford/Lincoln hybrids will be delivered, sold, and serviced at local Ford and Lincoln dealers.

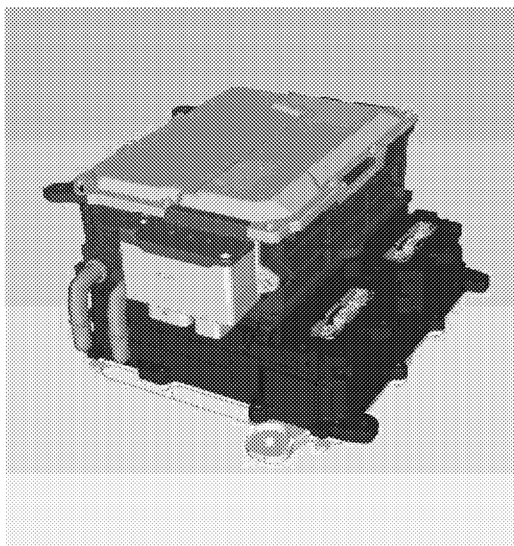
## Key Powertrain Components

### Engine



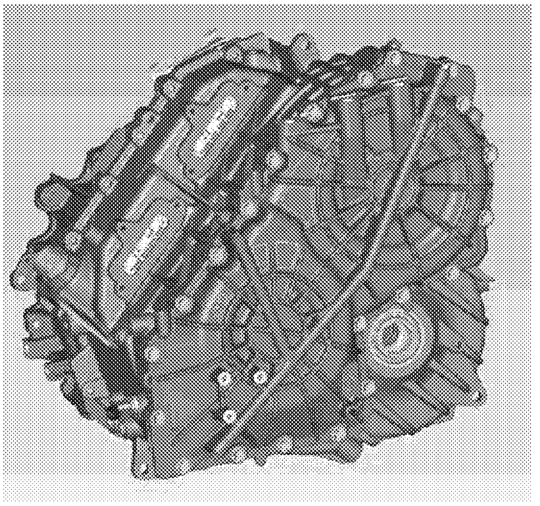
- I-4 Gasoline Engine
- Electronic Throttle Control
- Atkinson Cycle to improve efficiency by reducing pumping losses
    - For Otto Cycle, expansion ratio equals compression ratio
    - Atkinson Cycle expansion ratio greater than compression ratio
- Leaves intake valve open longer during compression stroke pushing air back into intake manifold
- Operates with less vacuum and greater throttle opening to maintain air charge

### Inverter Control Module (ISC)



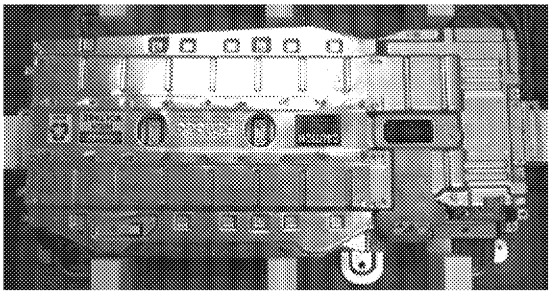
- Main hybrid control module
- Vehicle energy management functions
- Low level motor & gen control electronics and software
- Power electronics (motor and generator)
- Voltage boost converter
- Integrated heat exchanger
- Chassis mounted

## Transaxle



- 64 kW Permanent Magnet AC Generator Motor
- 88 kW Permanent Magnet AC Traction Motor
- Connected to ISC by 3-phase cables for each motor
- Planetary gear set and final drive gears
- Connected to front 2-wheel or all-wheel driveline

## Battery

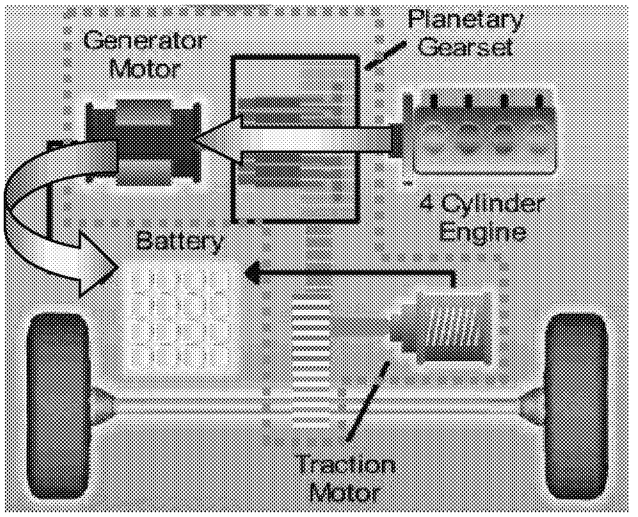


- Lithium-Ion battery chemistry
- Nearly twice the power density of previous model
- 35 kW power rating (new)

## Propulsion Modes

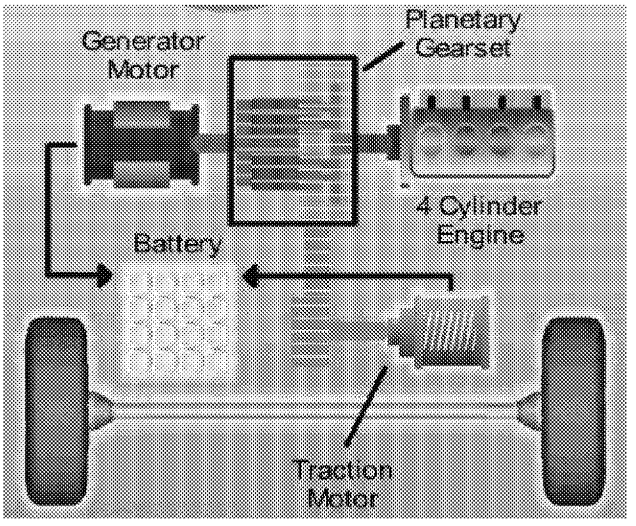
### Series Mode

- Used only when vehicle is not moving and the engine is running
- Engine may be running for battery charging, cabin or battery temperature control, or catalyst warm-up.



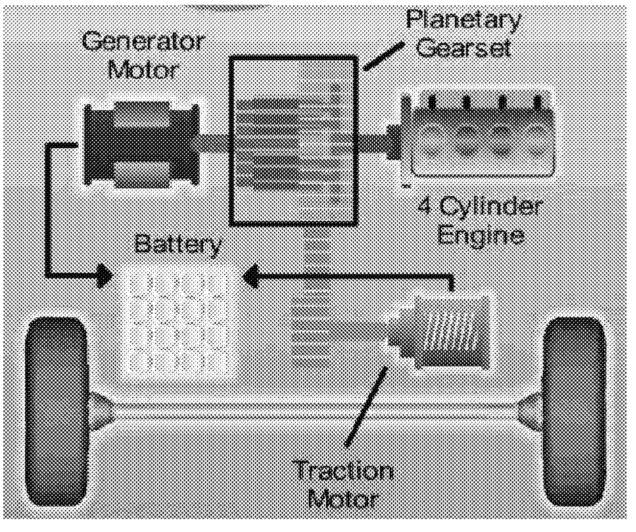

### Positive Split Mode

- Engine is ON and driving the generator motor to produce electricity
- Power from the engine is split between the direct path to the road and the path through the generator motor
- Generator power can flow to the battery or to the traction motor
- The traction motor can operate as a motor or a generator to make up the difference between the engine power and the desired power
- This is the preferred mode whenever the battery needs to be charged or when at moderate loads and low vehicle speeds

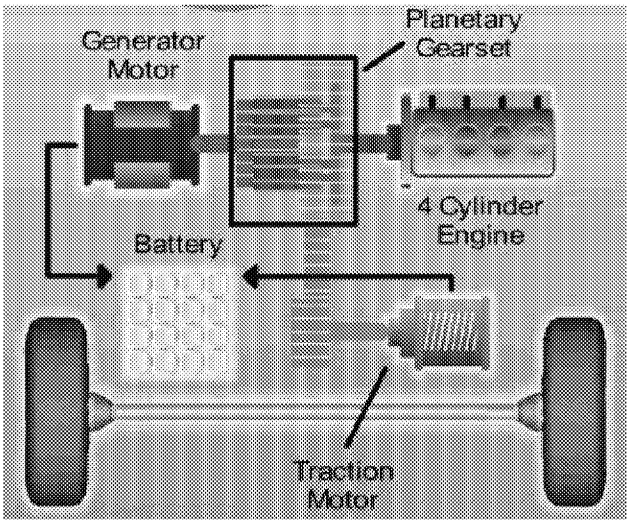



### Negative Split Mode

- The engine is on and the generator motor consumes electrical energy to reduce engine speed
- The traction motor can operate as a motor or a generator to make up the difference between the engine power and the desired power
- Typical highway mode
- Occurs when the engine needs to be on, the system can not be operated in parallel mode and the battery is charged near its upper limit



**Electric Mode**




- The vehicle is propelled by stored electrical energy only
- The engine is turned off
- The tractive torque supplied from the traction motor
- Preferred mode whenever the desired power is low enough such that it can be produced more efficiently by electrical system than engine
- Preferred mode in reverse because the engine can not deliver reverse torque
- Separate electric pump maintains power assisted steering

**City & Highway Traffic Scenarios**

## Stopped
- The engine will be off unless it needs to be on for reasons other than tractive power (Max A/C, vacuum, catalyst temp, heat, purge, low SOC)

## Launching
- At low speed or low power demand, the launch mode will be electric, unless the engine needs to be on for other reasons.
- At moderate speed or high desired power, the engine will come on.

## Entering highway or Passing
- At high acceleration demand, the engine power will be boosted with battery power through the traction motor to provide quick V-6 like response.

## Cruising
- At light load, the system may operate in parallel, positive split or negative split mode depending on the battery charge.
- At heavy load (due to high speeds, weight, towing or grade), the system will be limited to engine only performance (no battery support).
- Limited regenerative braking will be used.

## Exiting highway
- Provides an opportunity for regenerative braking.

## Braking
- At high speed, the engine torque is ramped down, the traction motor regenerates to a limit and the foundation brakes are applied as necessary (at the traction motor or battery regen limits).
- At moderate and low speed, the engine will be turned off.

# PHEV On Board Charger

## Charge Fault HMI (Human Machine Interface) On the Vehicle

### Vehicle Interior

- Cluster - Upon a charger fault, the BCCM and BECM can request the P/T malfunction indicator on the instrument cluster (amber wrench light). No specific message to point to the charge system which is similar to other onboard requests for this telltale.
- 8” Centerstack Screen - A charging fault message will be displayed in 8” centerstack.

### Vehicle Exterior

The vehicle will have a light ring around the charge port located on the driver’s fender. Upon a charge fault, all segments of the light ring will flash rapidly for 20-30 minutes.

Lighted ring indicates fault and state of charge

Ring illuminates in 4 segments representing 25% increments of battery state of charge

## Charge Fault HMI Near the Vehicle

### 120V Convenience Cord

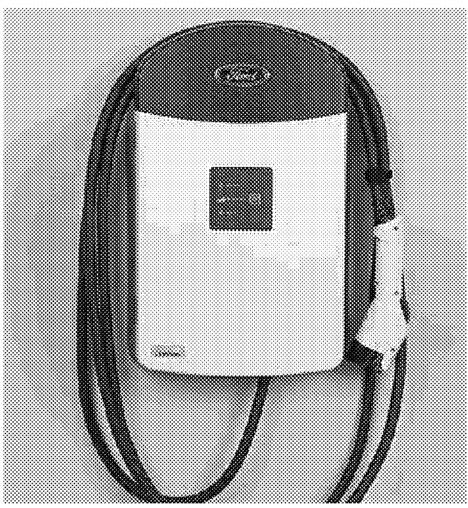
The convenience cord includes a CCID box with HMI display. A triangle with a (!) LED in the center indicates the following fault conditions:

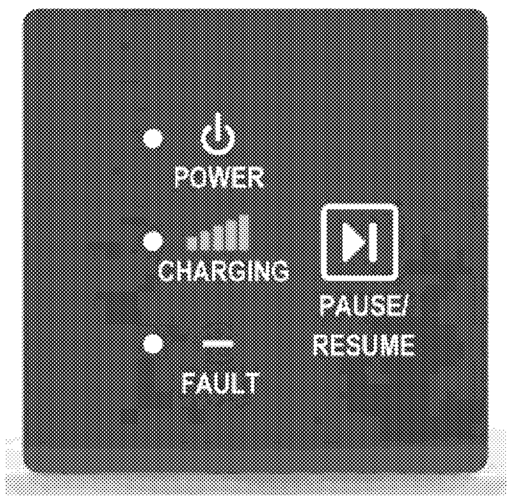
- CCID self test failure
- CCID microprocessor failure
- GFCI final fault
- Over current protection “final” fault

### 240V Wall Mount Charger

Red LED light illuminates indicating fault conditions. LED blinks unique codes depending on fault:

- Vehicle fault – 1x / 2 sec
- Contactor fault – 1x / 1 sec
- CCID fault – 2x / 1 sec
- Ground missing – 10x / 1 sec
- Failed internal self test – on steady





## Charge Fault HMI Remote from the Vehicle

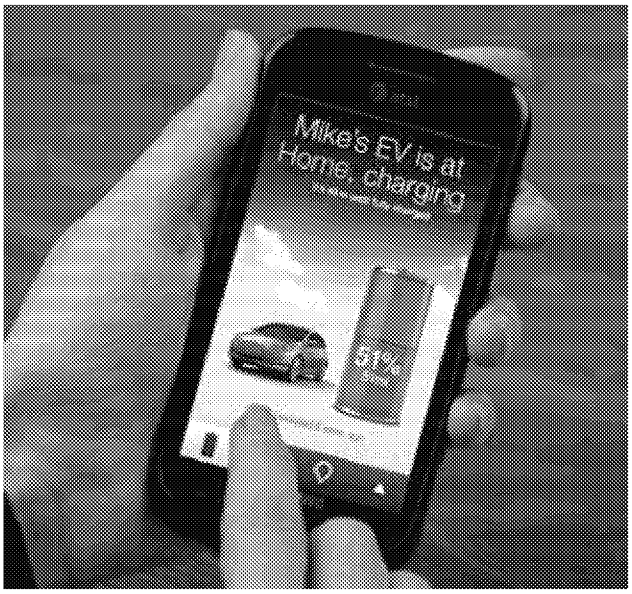
### MyFord Mobile App

Standard feature allowing cellular communication between vehicle and cell phone/computer
New vehicle purchase includes pre-paid 5 year subscription (renewable)
Upon charge fault, automatic alerts will be sent to the owner's cell phone and/or computer via text/email message.
The following reasons will trigger an alert:

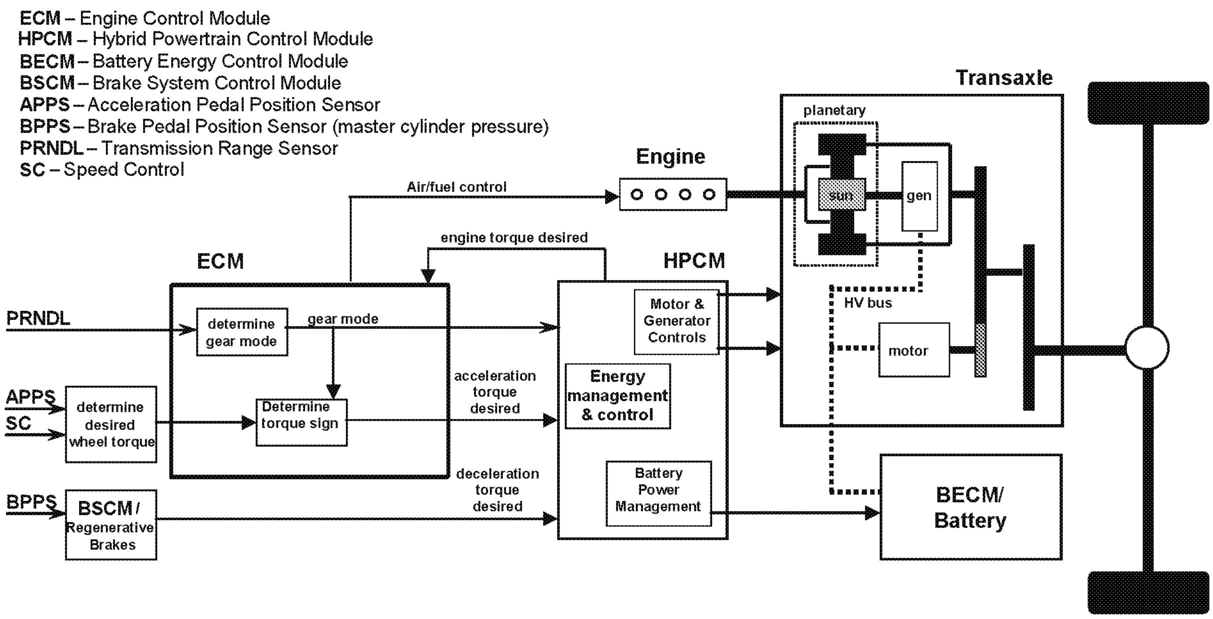
- Charging Fault (during charging only)
- Scheduled Charge Not Occurring
- Accidental Unplug - if charger is unplugged and vehicle not driven within 15 minutes

Upon request by owner, MyFord Mobile App also sends vehicle reports containing other information that could point to a charging fault:

- Charge status, including: generic fault (not known if in the car or out of the car), fault inside car, fault outside car, charge in progress, charge scheduled, and charge complete
- Plug status
- Battery health – if BECM not requesting telltale, health is ok



# Ford HEV Powertrain Control System




The Hybrid Electric Vehicle Control System uses four modules to control hybrid electric powertrain functions:

The Engine Control Module (ECM) monitors driver inputs and controls engine related functions.

The Hybrid Powertrain Control Module (HPCM) interprets driver inputs and controls energy management and generator and motor functions.

The Battery Energy Control Module (BECM) controls the high voltage battery pack.

The Brake System Control Module (BSCM) monitors driver braking requests and controls the braking functions.

All these modules use CAN communication for all diagnostic functions and normal-mode communications.

The ECM is a stand-alone OBD-II control module and meets all J1979 requirements. These include generic DIDs, freeze frame storage, pending and confirmed DTC retrieval and clearing, Mode 06 test data, Mode 08 evap system test, Mode 09 VIN, CALID and CVN, and Mode 0A Permanent DTCs. The OBD-II monitors for the engine are similar to the monitors used by a conventional gasoline vehicle. The basic difference between a conventional gasoline engine and the hybrid engine is that the engine often shuts down while in electric mode. This sometimes requires active intervention by the diagnostic executive to ensure that all OBD-II monitor can complete.

The HPCM is a stand-alone OBD-II control module and meets all J1979 requirements. These include generic DIDs, freeze frame storage, pending and confirmed DTC retrieval and clearing, and Mode 09 CALID and CVN, and Mode 0A Permanent DTCs. Some of the OBD-II monitors for hybrid system are similar to the monitors used by a conventional transmission; however, many of the monitors are unique to the hybrid generator and motor sensors and controls. The HPCM is housed within the Inverter Control System (ISC) models, and is not serviceable with the exception of reflashing memory.

The Battery Energy Control Module (BECM) is a stand-alone OBD-II control module and meets all J1979 requirements. These include generic PIDs, freeze frame storage, pending and confirmed DTC retrieval and clearing, and Mode 09 CALID and CVN. The BECM is housed within the battery pack and is not serviceable with the exception of reflashing memory. As a result, the BECM supports J1979 Mode 09 CALID and CVN.

The Brake System Control Module (BSCM) is not an OBD-II control module because there are no regenerative braking faults that affect emissions.

## Catalyst Efficiency Monitor

The Catalyst Efficiency Monitor uses an oxygen sensor after the catalyst to infer the hydrocarbon efficiency based on oxygen storage capacity of the ceria and precious metals in the washcoat. Under normal, closed-loop fuel conditions, high efficiency catalysts have significant oxygen storage. This makes the switching frequency of the rear HO2S very slow and reduces the amplitude. As catalyst efficiency deteriorates due to thermal and/or chemical deterioration, its ability to store oxygen declines and the post-catalyst HO2S signal begins to switch more rapidly with increasing amplitude. The predominant failure mode for high mileage catalysts is chemical deterioration (phosphorus deposition on the front brick of the catalyst), not thermal deterioration.

### Integrated Air/Fuel Method

The Integrated Air/Fuel Catalyst Monitor assesses the oxygen storage capacity of a catalyst after a fuel cut event. The monitor integrates how much excess fuel is needed to drive the monitored catalyst to a rich condition starting from an oxygen-saturated, lean condition. Therefore, the monitor is a measure of how much fuel is required to force catalyst breakthrough from lean to rich. To accomplish this, the monitor runs during fuel reactivation following a Decel Fuel Shut Off (DFSO) event. The monitor completes after a calibrated number of DFSO monitoring events have occurred. The IAF catalyst monitor can be used with either a wide range O2 sensor (UEGO) or a conventional switching sensor (HEGO).

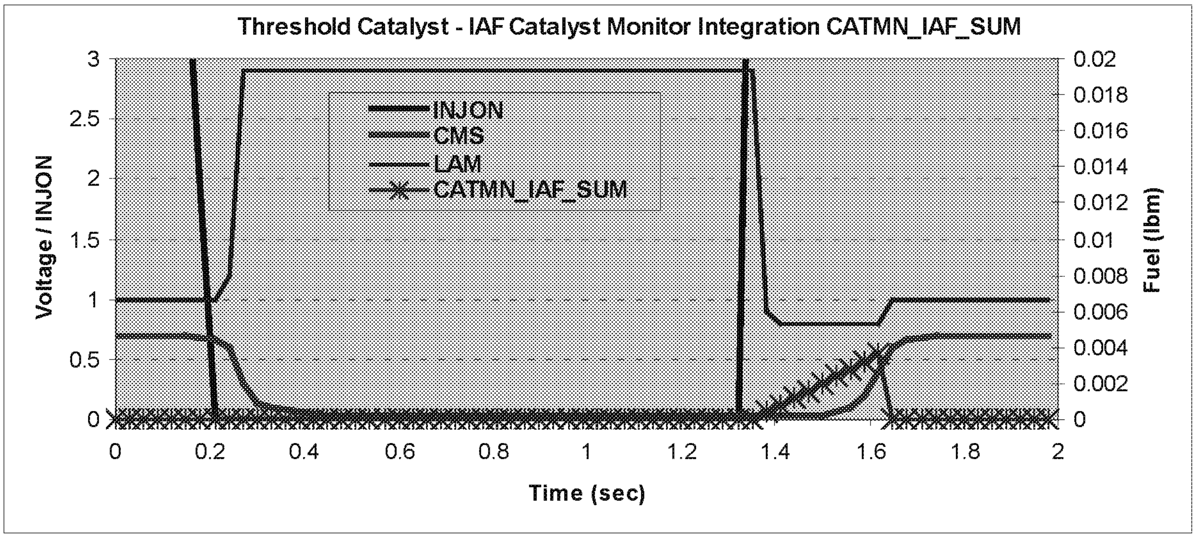
Functionally, the equation is:

$$IAF = \int \left( \frac{Fuel\_needed\_for\_stoich}{Fuel\_Measured} - Fuel\_needed\_for\_stoich \right)$$

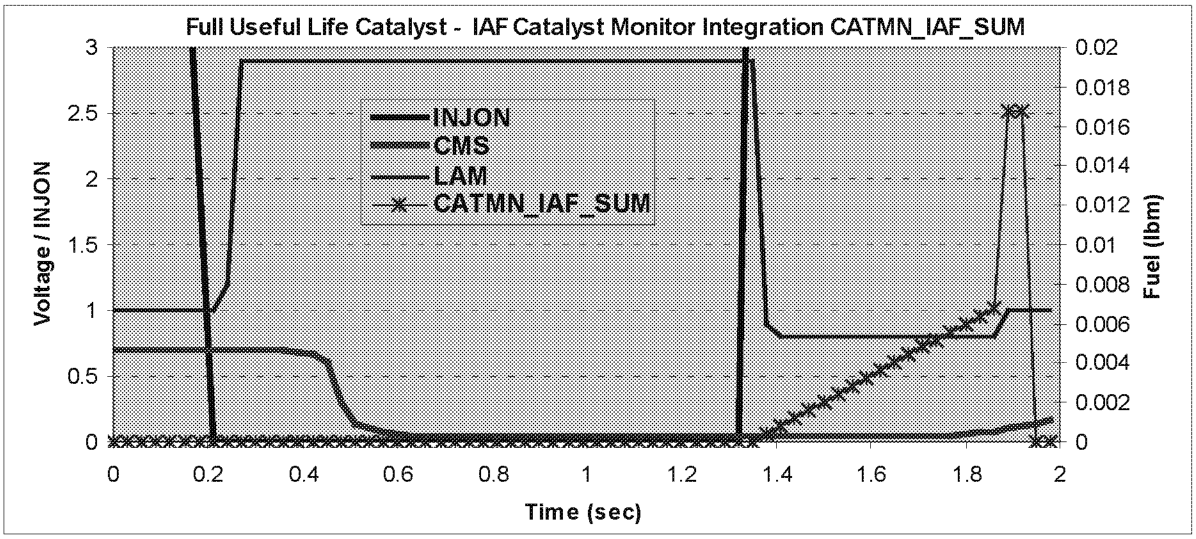
where the units are in pounds mass of fuel.

The monitor runs during reactivation fueling following an injector cut. The diagram below shows examples of one DFSO event with a threshold catalyst and with a Full Useful Life catalyst where:

- INJON = # of injectors on.
- CMS is the catalyst monitor sensor voltage. When the rear O2 sensor crosses 0.45 volts (i.e. rich) the monitor will complete for the given DFSO event.
- LAM (LAMBDA) is the front O2 sensor (UEGO) signal.
- CATMN_IAF_SUM is the integral from the equations above (Y axis on the right).




In this example, CATMN_IAF_SUM is small because it doesn't take much fuel to break though a low oxygen storage threshold catalyst.




In this example, CATMN_IAF_SUM is much larger because it takes a substantial amount of fuel to break though a high oxygen storage threshold catalyst.

There are two sets of entry conditions into the IAF catalyst monitor. The high level entry conditions determine that the monitor would like to run following the next injector fuel cut event. The lower level entry conditions determine that the fuel cut-off event was suitable for monitoring and the monitor will run as soon as the injectors come back on.

1. The high level entry conditions are met when:

   - There are no senor/hardware faults
   - The base monitor entry conditions have been met (ECT, IAT, cat temp, fuel level, air mass)
   - Required number of DFSO monitoring event have not yet completed

2. The lower level entry conditions are met when:

   - The injectors are off
   - The catalyst is believed to be saturated with oxygen (rear O2 indicates lean)
   - The catalyst/rear O2 has been rich at least once since the last monitor event.

## General Catalyst Monitor Operation

Rear HO2S sensors can be located in various ways to monitor different kinds of exhaust systems. In-line engines and many V-engines are monitored by individual bank. A rear HO2S sensor is used along with the front, fuel-control HO2S sensor for each bank. Two sensors are used on an in-line engine; four sensors are used on a V-engine. Some V-engines have exhaust banks that combine into a single underbody catalyst. These systems are referred to as Y-pipe systems. They use only one rear HO2S sensor along with the two front, fuel-control HO2S sensors. Y-pipe system use three sensors in all. For Y-pipe systems which utilize switching front O2 sensors, the two front HO2S sensor signals are combined by the software to infer what the HO2S signal would have been in front of the monitored catalyst. The inferred front HO2S signal and the actual single, rear HO2S signal is then used to calculate the switch ratio.

Many vehicles monitor less than 100% of the catalyst volume – often the first catalyst brick of the catalyst system. Partial volume monitoring is done on LEV-II vehicles in order to meet the 1.75 * emission-standard threshold for NMHC and NOx. The rationale for this practice is that the catalysts nearest the engine deteriorate first, allowing the catalyst monitor to be more sensitive and illuminate the MIL properly at lower emission standards.

Many applications that utilize partial-volume monitoring place the rear HO2S sensor after the first light-off catalyst can or, after the second catalyst can in a three-can per bank system. (A few applications placed the HO2S in the middle of the catalyst can, between the first and second bricks.)

The new Integrated Air/Fuel Catalyst Monitor can be used to monitor the entire catalyst volume, even on LEV-II vehicles.

Index ratios for ethanol (Flex fuel) vehicles vary based on the changing concentration of alcohol in the fuel. The malfunction threshold typically increases as the percent alcohol increases. For example, a malfunction threshold of 0.5 may be used at E10 (10% ethanol) and 0.9 may be used at E85 (85% ethanol). The malfunction thresholds are therefore adjusted based on the % alcohol in the fuel. (Note: Normal gasoline is allowed to contain up to 10% ethanol (E10)).

Vehicles with the Index Ratio Method Using a Switching HO2S Sensor employ an Exponentially Weighted Moving Average (EWMA) algorithm to improve the robustness of the catalyst monitor. During normal customer driving, a malfunction will illuminate the MIL, on average, in 3 to 6 driving cycles. If KAM is reset (battery disconnected) or DTCs are cleared, a malfunction will illuminate the MIL in 2 driving cycles. See the section on EWMA for additional information.

Vehicles with the Index Ratio Method Using a Wide Range HO2S Sensor (UEGO) or the Integrated Air/Fuel catalyst monitor employ an improved version of the EWMA algorithm.

The EWMA logic incorporates several important CARB requirements. These are:

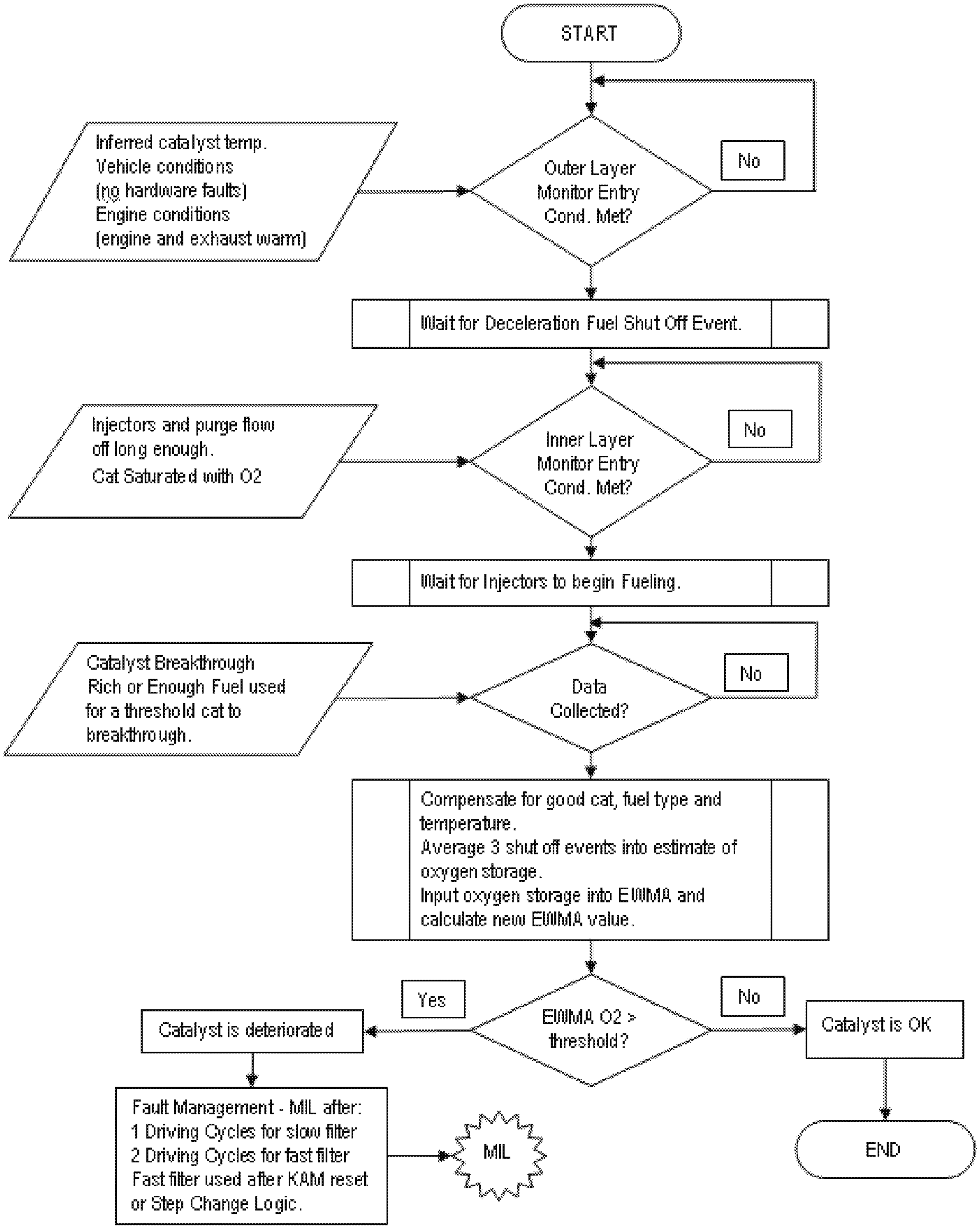
- Fast Initial Response (FIR): The first 4 tests after a battery disconnect or code clear will process unfiltered data to quickly indicate a fault. The FIR will use a 2-trip MIL. This will help the service technician determine that a fault has been fixed.
- Step-change Logic (SCL): The logic will detect an abrupt change from a no-fault condition to a fault condition. The SCL will be active after the $4^{th}$ catalyst monitor cycle and will also use a 2-trip MIL. This will illuminate the MIL when a fault is instantaneously induced.
- Normal EWMA (NORM): This is the normal mode of operation and uses an Exponentially Weighted Moving Average (EWMA) to filter the catalyst monitor test data. It is employed after the $4^{th}$ catalyst test and will illuminate a MIL during the drive cycle where the EWMA value exceeds the fault threshold. (1 trip MIL).

Starting in the 2010 ½ Model Year and later, the catalyst monitor will employ catalyst break-in logic. This logic will prevent the catalyst monitor from running until after a catalyst break-in period.

The catalyst monitor will not run on a new vehicle from the assembly plant until 60 minutes of time above a catalyst temperature (typically 800 to 1100 deg F) has been accumulated or 300 miles has elapsed.

New modules at the assembly plant will have an NVRAM flag initialized to delay the catalyst monitor. Service modules and re-flash software will have the flag set to allow that catalyst monitor to run. The flag cannot be reset to delay the catalyst monitor from running by any tool or service procedure.

Integrated Air Fuel Catalyst Monitor



| CATALYST MONITOR OPERATION: | |
|---|---|
| DTCs | P0420 Bank 1 |
| Monitor execution | once per driving cycle |
| Monitor Sequence | HO2S response test complete and no DTCs (P0133/P0153) prior to calculating switch ratio, no SAIR pump stuck on DTCs (P0412/P1414), no evap leak check DTCs (P0442/P0456), no EGR stuck open DTCs (P0402) |
| Sensors OK | ECT, IAT, TP, VSS, CKP, MAF, no misfire DTCs (P0300, P0310), no ignition coil DTCs (P0351-P0358), no fuel monitor DTCs (P0171, P0172, P0174. P0175), no VCT DTCs (P0010-P0017, P052A, P052B, P0344, P0365, P0369- bank1) (P0018 thru P0025,P052C, P052D, P0349, P0390, P0394- bank2 ).no evap system DTCs (P0443, P0446, P0455, P0457, P1450), no ETC system DTCs (P0122, P0123, P0222, P0223, P02135) (P2101, P2107, P2111, P2112) (P0600, P060A, P060B, P060C, P061B, P061C, P061D, P1674, U0300). |
| Monitoring Duration | Approximately 700 seconds during appropriate FTP conditions (approximately 100 to 200 oxygen sensor switches are collected) for switching O2 control sensors<br>Approximately 10 to 20 seconds for wide range O2 index ratio monitor.<br>3 Decel Fuel Cutoff events for IAF catalyst monitor |

| TYPICAL IAF CATALYST MONITOR ENTRY CONDITIONS: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Coolant Temp | 125 °F | 220 °F |
| Intake Air Temp | 20 °F | 140 °F |
| Inferred catalyst mid-bed temperature | 800 °F | 1590 °F |
| Fuel Level | 15% | |
| Air Mass | | 4.0 lb/min |
| Minimum inferred rear O2 sensor temperature | 800 °F | |
| Fuel monitor learned within limits | 98% | 102% |
| Rear O2 sensor rich since last monitor attempt | 0.45 volts | |
| Rear O2 sensor lean with injectors off (voltage needed to enter monitor) | | 0.1 volts |
| Rear O2 sensor reads rich after fuel turned back on (voltage needed to complete monitor) | 0.45 volts | |

| TYPICAL MALFUNCTION THRESHOLDS: |
|---|
| Catalyst monitor index ratio > 0.75 (bank monitor) |

Mode $06 reporting for IAF Catalyst Monitor

The catalyst monitor results are converted to a ratio for Mode $06 reporting to keep the same look and feel for the service technician. The equation for calculating the Mode $06 monitor result is:

1 – (Actual reactivation fuel/ Good catalyst reactivation fuel)

Good catalyst reactivation fuel is intended to represent what the monitor would measure for a green catalyst.

| J1979 CATALYST MONITOR MODE $06 DATA | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | |
| $21 | $80 | Bank 1 index-ratio and max. limit | unitless |

** NOTE: In this document, a monitor or sensor is considered OK if there are no DTCs stored for that component or system at the time the monitor is running.

# Misfire Monitor

The HEV uses the Low Data Rate misfire monitor. The LDR system is capable of meeting "full-range" misfire monitoring requirements on 4-cylinder engines. The software allows for detection of any misfires that occur 6 engine revolutions after initially cranking the engine. This meets the new OBD-II requirement to identify misfires within 2 engine revolutions after exceeding the warm drive, idle rpm.

## Low Data Rate System

The LDR Misfire Monitor uses a low-data-rate crankshaft position signal, (i.e. one position reference signal at 10 deg BTDC for each cylinder event). The PCM calculates crankshaft rotational velocity for each cylinder from this crankshaft position signal. The acceleration for each cylinder can then be calculated using successive velocity values. The changes in overall engine rpm are removed by subtracting the median engine acceleration over a complete engine cycle. The crankshaft acceleration is then processed by two algorithms. The first is optimized for detection of sporadic and single cylinder patterns of misfire; the second is optimized for multi-cylinder patterns. The resulting deviant cylinder acceleration values are used in evaluating misfire in the "General Misfire Algorithm Processing" section below.

## Generic Misfire Algorithm Processing

The acceleration that a piston undergoes during a normal firing event is directly related to the amount of torque that cylinder produces. The calculated piston/cylinder acceleration value(s) are compared to a misfire threshold that is continuously adjusted based on inferred engine torque. Deviant accelerations exceeding the threshold are conditionally labeled as misfires. A threshold multiplier is used during startup CSER to compensate the thresholds for the reduction in signal amplitude during spark retard conditions.

The calculated deviant acceleration value(s) are also evaluated for noise. Normally, misfire results in a non-symmetrical loss of cylinder acceleration. Mechanical noise, such as rough roads or high rpm/light load conditions, will produce symmetrical, positive acceleration variations. A noise limit is calculated by applying a negative multiplier to the misfire threshold. If the noise limit is exceeded, a noisy signal condition is inferred and the misfire monitor is suspended for a brief interval. Noise-free deviant acceleration exceeding a given threshold is labeled a misfire.

The number of misfires is counted over a continuous 200 revolution and 1000 revolution period. (The revolution counters are not reset if the misfire monitor is temporarily disabled such as for negative torque mode, etc.) At the end of the evaluation period, the total misfire rate and the misfire rate for each individual cylinder is computed. The misfire rate evaluated every 200 revolution period (Type A) and compared to a threshold value obtained from an engine speed/load table. This misfire threshold is designed to prevent damage to the catalyst due to sustained excessive temperature (1650°F for Pt/Pd/Rh advanced washcoat and 1800°F for Pd-only high tech washcoat). If the misfire threshold is exceeded and the catalyst temperature model calculates a catalyst mid-bed temperature that exceeds the catalyst damage threshold, the MIL blinks at a 1 Hz rate while the misfire is present. If the misfire occurs again on a subsequent driving cycle, the MIL is illuminated.

If a single cylinder is determined to be consistently misfiring in excess of the catalyst damage criteria, the fuel injector to that cylinder will be shut off for 30 seconds to prevent catalyst damage. Up to two cylinders may be disabled at the same time on 6 and 8 cylinder engines and one cylinder is disabled on 4 cylinder engines. This fuel shut-off feature is used on all engines starting in the 2005 MY. After 30 seconds, the injector is re-enabled. If misfire on that cylinder is again detected after 200 revs (about 5 to 10 seconds), the fuel injector will be shut off again and the process will repeat until the misfire is no longer present. Note that ignition coil primary circuit failures (see CCM section) will trigger the same type of fuel injector disablement.

The misfire rate is also evaluated every 1000 rev period and compared to a single (Type B) threshold value to indicate an emission-threshold malfunction, which can be either a single 1000 rev exceedence from startup or four subsequent 1000 rev exceedences on a drive cycle after start-up. Some vehicles will set a P0316 DTC if the Type B malfunction threshold is exceeded during the first 1,000 revs after engine startup. This DTC is normally stored in addition to the normal P03xx DTC that indicates the misfiring cylinder(s). If misfire is detected but cannot be attributed to a specific cylinder, a P0300 is stored. This may occur on some vehicles at higher engine speeds, for example, above 3,500 rpm.

### Profile Correction

"Profile correction" software is used to "learn" and correct for mechanical inaccuracies in the crankshaft position wheel tooth spacing. Since the sum of all the angles between crankshaft teeth must equal 360°, a correction factor can be calculated for each misfire sample interval that makes all the angles between individual teeth equal. . The LDR misfire system will learn one profile correction factor per cylinder (ex. 4 correction factors for a 4 cylinder engine), while the HDR system will learn 36 or 40 correction factors depending on the number of crankshaft wheel teeth (ex. 36 for V6/V8 engines, 40 for V10 engines).

The corrections are calculated from several engine cycles of misfire sample interval data. The "mature" correction factors are the average of a selected number of samples. In order to assure the accuracy of these corrections, a tolerance is placed on the incoming values such that an individual correction factor must be repeatable within the tolerance during learning. This is to reduce the possibility of learning corrections on rough road conditions which could limit misfire detection capability and to help isolate misfire diagnoses from other crankshaft velocity disturbances.

To prevent any fueling or combustion differences from affecting the correction factors, learning is done during decel-fuel cutout. This can be done during closed-throttle, non-braking, de-fueled decelerations in the 60 to 40 mph range after exceeding 60 mph (likely to correspond to a freeway exit condition). In order to minimize the learning time for the correction factors, a more aggressive decel-fuel cutout strategy may be employed when the conditions for learning are present and are typically learned in a single 60 to 40 MPH deceleration, but can be learned during up to 3 such decelerations, or over a higher number of shorter duration decelerations..

For Hybrid Electric Vehicles profile is learned by using the electric drive to spin the crankshaft on the first engine shutdown during which time profile is calculated.

Since inaccuracies in the wheel tooth spacing can produce a false indication of misfire, the misfire monitor is not active until the corrections are learned. In the event of battery disconnection or loss of Keep Alive Memory the correction factors are lost and must be relearned. If the software is unable to learn a profile after three 60 to 40 mph decels, or for HEV's after 6 failed attempts to learn, a P0315 DTC is set.

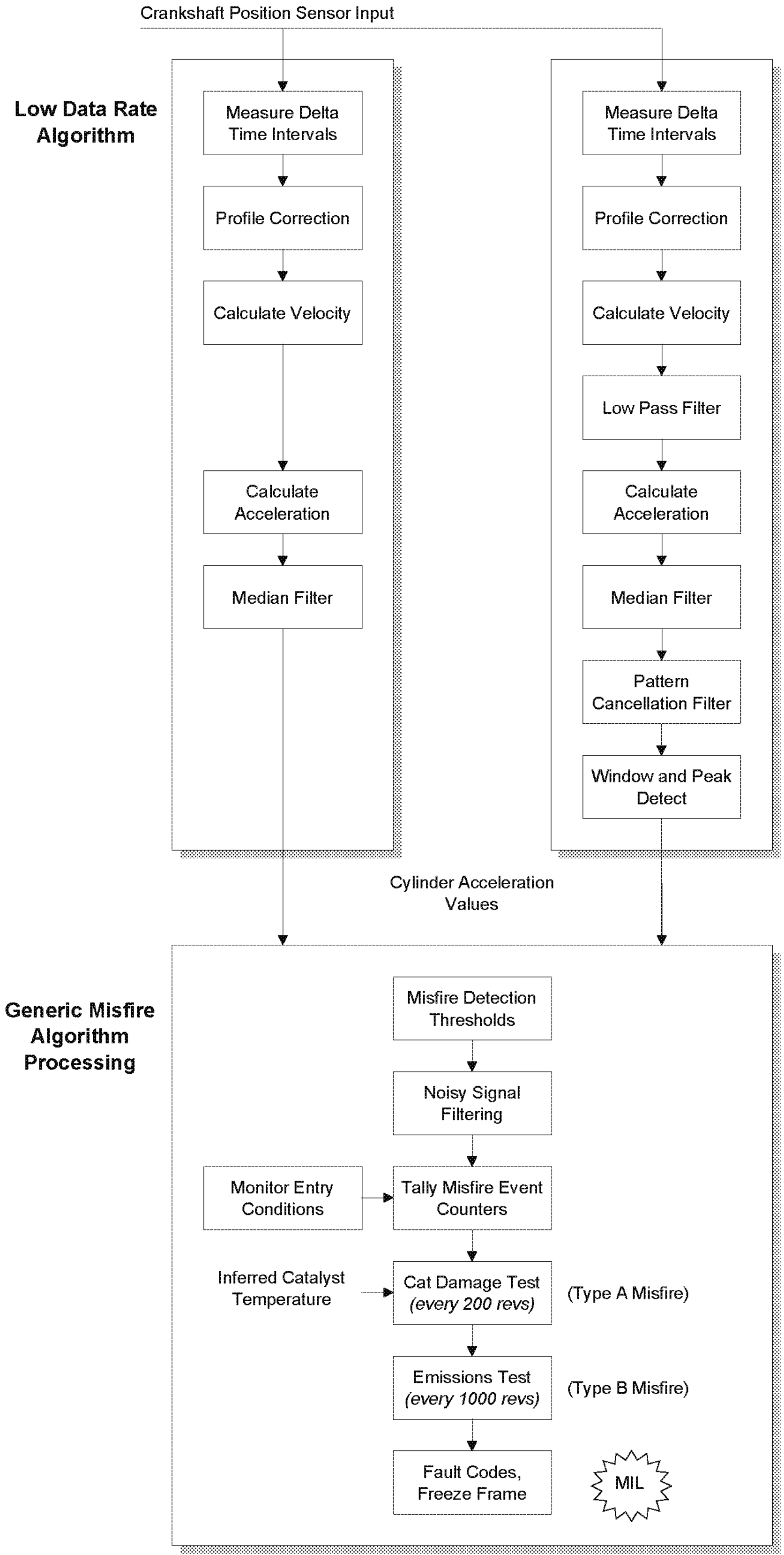
### Neutral Profile Correction and Non-Volatile Memory

Neutral profile learning is used at End of Line to learn profile correction via a series of one or more neutral engine rpm throttle snaps. This allows the Misfire Monitor to be activated at the Assembly Plant. A Test Tool command is required to enable this method of learning, so this method will only be performed by a Plant or Service technician. Learning profile correction factors at high-speed (3,000 rpm) neutral conditions versus during 60-40 mph decels optimizes correction factors for higher rpms where they are most needed and eliminates driveline/transmission and road noise effects. This improves signal to noise characteristics which means improved detection capability.

The profile correction factors learned at the Assembly Plant are stored into non-volatile memory. This eliminates the need for specific customer drive cycles. However, misfire profiles may need to be relearned in the Service Bay using a service procedure if major engine work is done or the PCM is replaced. (Re-learning is not required for a reflash.)

The engine shutdown profile learning algorithm has been left active in the software as a backup.

## Low Data Rate and High Data Rate Systems



| Misfire Monitor Operation: | |
|---|---|
| DTCs | P0300 to P0304 (general and specific cylinder misfire)<br>P0315 (unable to learn profile)<br>P0316 (misfire during first 1,000 revs after start-up)<br>P1336 (unable to synch CKP and CMP signals) |
| Monitor execution | Continuous, misfire rate calculated every 200 or 1000 revs |
| Monitor Sequence | None |
| Sensors OK | CKP, CMP, MAF, ECT/CHT |
| Monitoring Duration | Entire driving cycle (see disablement conditions below) |

| Typical misfire monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Time since engine start-up | 0 seconds | 0 seconds |
| Engine Coolant Temperature | 20 $^{o}$F | 250 $^{o}$F |
| RPM Range (Full-Range Misfire certified, with 2 rev delay) | 2 revs after exceeding 150 rpm below “drive” idle rpm | 5900 rpm |
| Profile correction factors learned in NVRAM | Yes | |
| Fuel tank level | 15% | |

| Typical misfire temporary disablement conditions: |
|---|
| Temporary disablement conditions: |
| Closed throttle decel (negative torque, engine being driven) > -100 ft lbs |
| Fuel shut-off due to vehicle-speed limiting or engine-rpm limiting mode |
| High rate of change of torque (heavy throttle tip-in or tip out) > -1024 deg/sec or 1023 deg/sec; > -200 ft lbs/sec or > 200 ft lbs/sec |

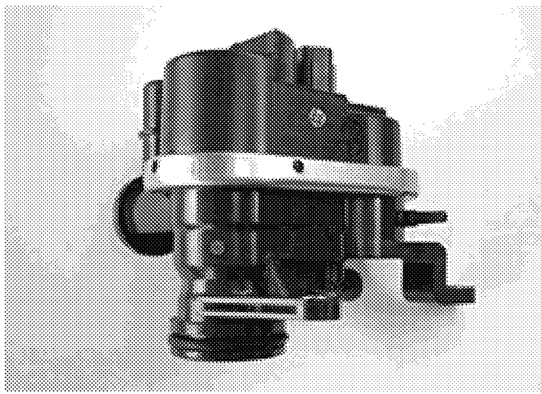
| Typical misfire monitor malfunction thresholds: |
|---|
| Type A (catalyst damaging misfire rate): misfire rate is an rpm/load table ranging from 20% at idle to 5% at high rpm and loads |
| Type B (emission threshold rate): 0.89% |

| J1979 Misfire Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | |
| A1 | $80 | Total engine misfire and catalyst damage misfire rate (updated every 200 revolutions) | percent |
| A1 | $81 | Total engine misfire and emission threshold misfire rate (updated every 1,000 revolutions) | percent |
| A1 | $82 | Highest catalyst-damage misfire and catalyst damage threshold misfire rate (updated when DTC set or clears) | percent |
| A1 | $83 | Highest emission-threshold misfire and emission threshold misfire rate (updated when DTC set or clears) | percent |
| A1 | $84 | Inferred catalyst mid-bed temperature | $^{o}$C |
| A2 – AD | $0B | EWMA misfire counts for last 10 driving cycles | events |
| A2 – AD | $0C | Misfire counts for last/current driving cycle | events |
| A2 – AD | $80 | Cylinder X misfire rate and catalyst damage misfire rate (updated every 200 revolutions) | percent |
| A2 – AD | $81 | Cylinder X misfire rate and emission threshold misfire rate (updated every 1,000 revolutions) | percent |

## Evap Monitor Overview

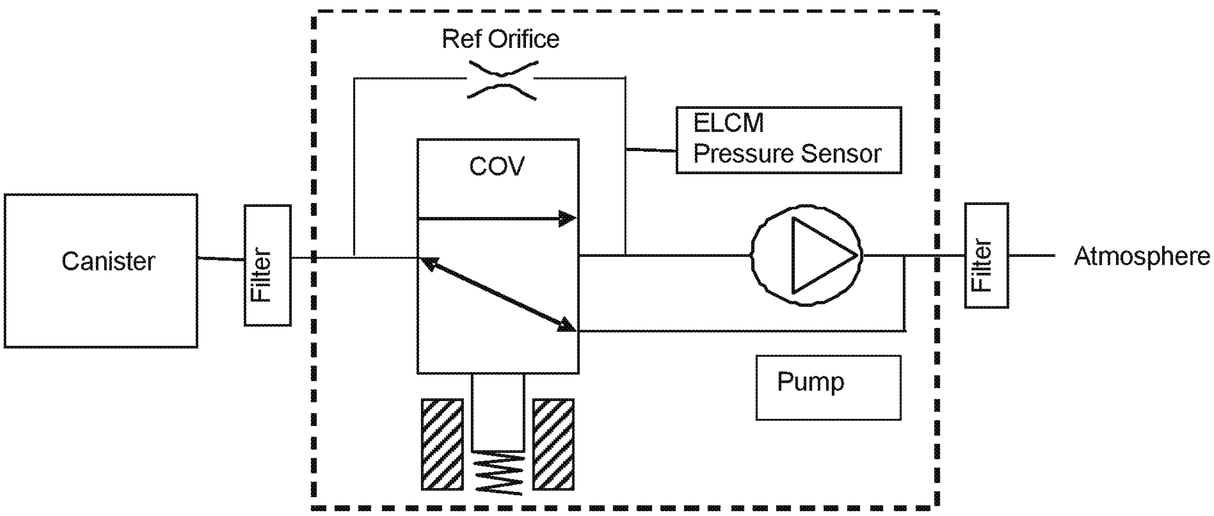
For 2013 MY, a new family of Hybrid Electric Vehicles (HEV) will be introduced. Some of these vehicles will be able to charge the battery by plugging the vehicle into the grid as well as using an engine –driven generator and regenerative brakes to charge the battery while driving (Plug in Hybrid Electric Vehicles (PHEV)); others will only be using an engine –driven generator and regenerative brakes to charge the battery while driving (Hybrid Electric Vehicles (HEV)). For both types of vehicle, depending on the vehicle drive cycle, there could be very little or no engine operation during the driving cycle. This poses a challenge as historically, evaporative system leak diagnostics has relied on engine vacuum to evacuate the fuel tank and perform a large portion of the leak check and purge flow diagnostics. Additionally, the Engine Off Natural Vacuum (EONV) test that runs after key off relies on a exhaust system to heat up underbody components and reject heat into the fuel tank. It is the cooling of the fuel in the tank that generates the vacuum that enables to EONV test to perform the 0.020" leak check. If the engine does not run, both of the current engine-running and engine –off evap system diagnostics are not feasible.

In spite of this, the OBD-II regulations still require manufacturers to monitor the evaporative system for leaks and to perform a functional purge flow check. One solution is to add a vacuum pump that can generate vacuum on demand to facilitate the evaporative system diagnostics. The system that is being used is manufactured by the Denso Corporation and is called Evaporative Leak Check Module (ELCM).

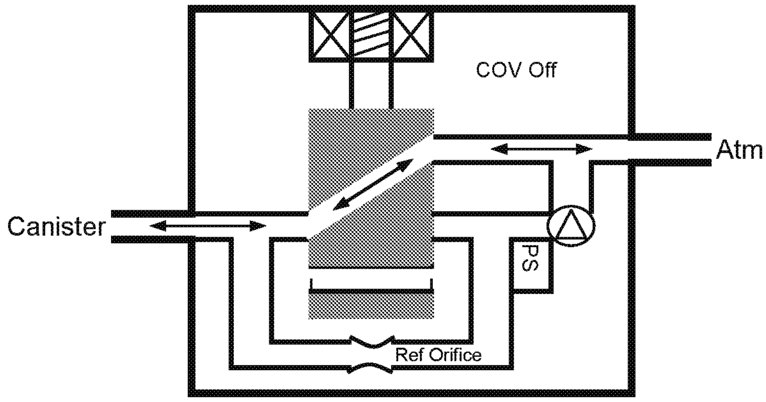


The ELCM consists of a vacuum pump, an absolute pressure sensor, a 0.020" reference orifice and a change-over valve (COV). The 0.020" reference orifice is used to obtain a 0.020" reference every time the monitor is run. This reference check becomes the threshold for passing or failing a 0.020" leak. Since the threshold is dynamically established at the beginning of the test, many of the noise/control factors (e.g. fuel level, ambient temperature, barometric pressure) are accounted for. The ELCM system is illustrated below:

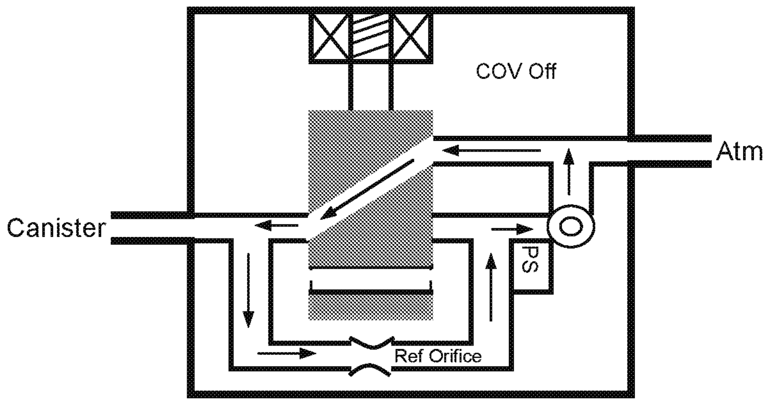
ELCM



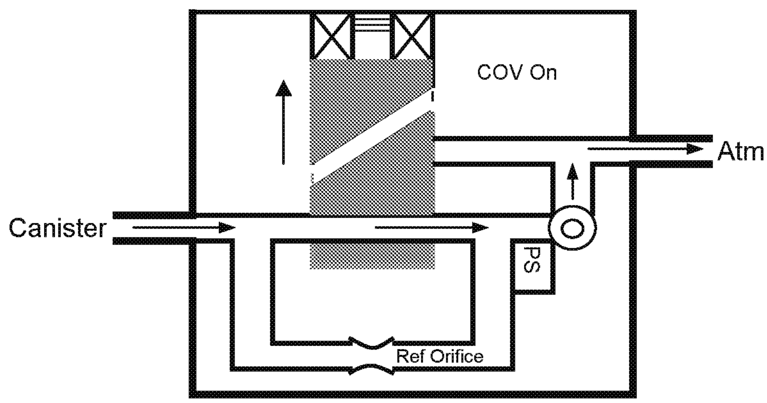
During normal operation, the ELCM is vented to atmosphere through the COV. This allows for purging during engine operation as well as fuel fill. During ELCM leak detection execution, the vacuum pump is turned on. With the pump on, vacuum is drawn across the reference orifice and the ensuing vacuum level becomes the threshold for pass/fail criteria. Once the reference is established, it is time to perform the actual leak testing. This is accomplished by energizing the COV and turning on the vacuum pump. Depending on the volume of the evaporative system being evacuated, it could take anywhere from 2 to15 minutes for the vacuum level to saturate. Once saturation vacuum is reached, the vacuum level is compared against the vacuum level when the reference check was performed. Vacuum levels lower than the reference check are considered to be fails and vacuum levels above the reference check are considered to be passes. The diagrams below illustrate this.




Typical purge flow/fuel fill configuration. Yellow denotes the vacuum/pressure path.

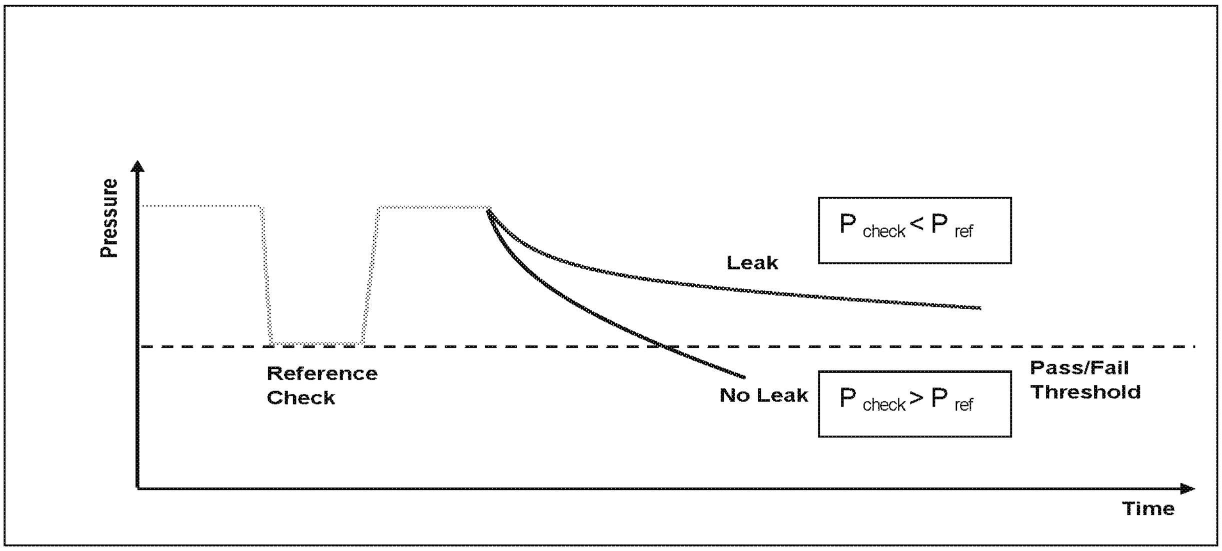



Typical reference check configuration (Pump ON). Yellow denotes the vacuum path.

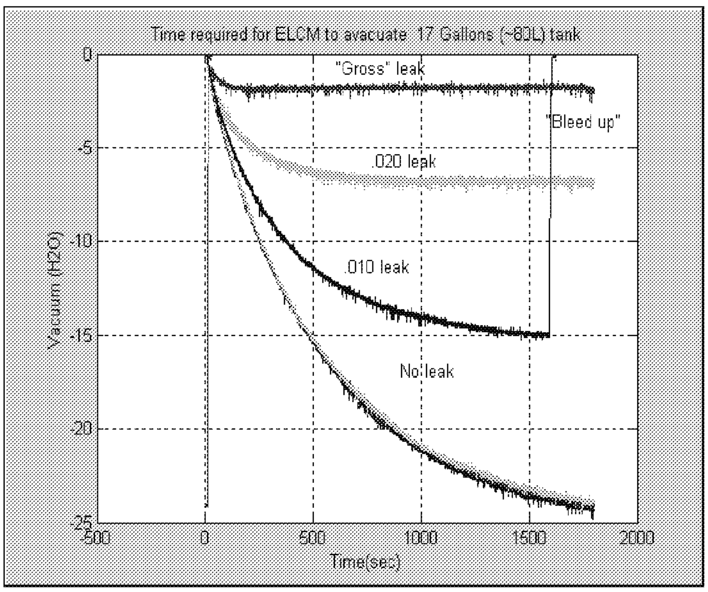



Typical system leak check configuration (Pump On, COV On). Yellow denotes the vacuum path.

Below is a typical plot of a test sequence. First, a reference check is obtained. The system is then relieved back to atmosphere before the COV is energized and the pump is turned on again. If the resulting vacuum signal crosses below the reference check line, then the system is deemed to be leak-free. If the vacuum signal "flat lines" above the reference check line, then the system is determined to have a leak > 0.020".




The ELCM leak detection test runs at key off if entry conditions such as vehicle soak, fuel level, ambient temperature, BARO, etc. are satisfied. The test sequence begins with a pump warm-up time of 5 minutes followed by a reference check calculation. Once the reference check is obtained, the pump is turned off which allows the vacuum to equalize to atmosphere. The changeover valve is then energized and the Evap system is evacuated. The pump stays on until the vacuum crosses the reference check threshold or the vacuum trace flat-lines above the reference check threshold.




In addition to running leak diagnostics, the evap monitor also performs numerous functional tests on the individual components that are used for the evap leak check, (i.e., stuck open/closed COV, stuck on/stuck off pump, restricted orifice, stuck open/stuck closed Fuel Tank Isolation Valve, stuck closed Canister Purge Valve) The monitor runs once per drive cycle during a key off condition and increments the Evap System IUMPR numerator once the ghost monitor completes. Rate based completion frequency (IUMPR) is reported via J1979 Mode$09. The ELCM system is used in sealed (PHEV) and non-sealed (HEV) evap systems. Although the algorithm between sealed and non-sealed applications differs slightly (sealed system has FTIV while non-sealed has VBV), the leak detection method remains the same.

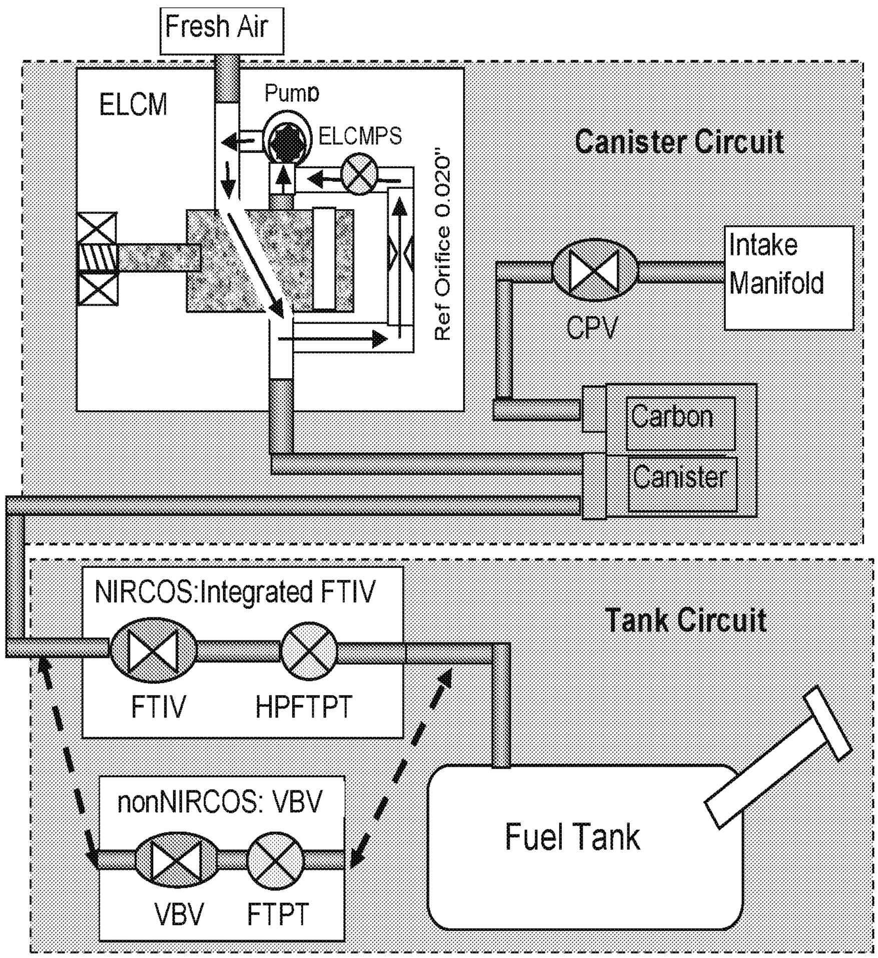
## Fuel Systems Hardware – Sealed (PHEV) vs non-Sealed (HEV)

HEVs use a traditional non-sealed evaporative system. This is because the engine is expected to run for extended periods of time on an HEV so fuel vapors will get purged on a regular basis.

- Uses traditional Canister Purge Valve (CPV)
- Uses traditional Vapor Blocking Valve (VBV)
- Uses traditional (low pressure) Fuel Tank Pressure Transducer (FTPT)
- ELCM replaces Canister Vent Valve (CVV).
- VBV de-energized state is open

Plug in HEVs (PHEV) use a sealed evaporative system. The sealed fuel system is designed to contain fuel vapors while not refueling. This is because the engine may not run for extended periods of time on a PHEV so fuel vapors do not get purged on a regular basis. Internally, the sealed system is known as a NIRCOS (Non-Integrated Refueling Canister Only System).

- Canister sized for refueling vapors only
- Uses a structurally improved steel fuel tank
- Tank pressure relief at -2.5 psi and 5.5 psi
- Requires an electric refueling system to relieve the pressure in the tank
- Uses traditional Canister Purge Valve (CPV)
- Uses High Pressure Fuel Tank Pressure Transducer (HPFTPT)
- Uses Fuel Tank Isolation Valve (FTIV) in place of Vapor Blocking Valve (VBV)
- FTIV de-energized state is closed
- When FTIV is closed, it splits the evap system into two separately diagnosable system – the "fuel tank side" and the "fresh air side"

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# EVAP System Monitor – Engine Running Diagnostics

The EVAP diagnostics can be split into two categories:

Engine Running Diagnostics (HEV and PHEV), consisting of:

- A purge flow/gross leak (P04ED)
- Excessive vacuum (P1450)
- Fresh air line blockage (P144B)
- Canister Purge Valve component checks (P0443)
- Vapor Blocking Valve stuck open (P2450) (HEV only)

Engine Off (After-run) Diagnostics, consisting of:

- The 0.020" /0.040" leak check
- All other EVAP system and component diagnostics are executed during the engine off period.

The engine running diagnostics are described below:

The **Canister Purge Valve (CPV)** output circuit is checked for opens and shorts (P0443)

Note that a stuck closed CPV generates a P04ED, a leaking or stuck open CPV generates a P1450.

| Canister Purge Valve Circuit Check Operation: | |
|---|---|
| DTCs | P0443 – Evaporative Emission System Purge Control Valve "A" Circuit |
| Monitor execution | engine running, continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to obtain smart driver status |

| Typical Canister Purge Valve Circuit Check malfunction thresholds: |
|---|
| P0443: open/shorted |

This test checks to see if the fresh air line to ELCM unit is clogged or restricted. The fresh air line flow test is performed with the engine running, the Change Over Valve (COV) off and purge flow commanded on.

| **Fresh Air Line Flow Check Operation:** | |
|---|---|
| DTCs | P144B - EVAP System Secondary Purge Vapor Line Restricted/Blocked |
| Monitor execution | engine running, once per driving cycle |
| Monitor Sequence | P1450 completed and OK |
| Sensors/Components OK | P0456, P0457, P24B9, P24BA, P24BB, P0100, P0102, P0103, P0106, P0107, P0108, P0720 |
| Monitoring Duration | |

| **Fresh Air Line Flow Check entry conditions** | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Air Mass | > 0 lbs/min | |
| Vehicle Speed | 0 mph | |
| BARO (<8,000 ft altitude) | 22.0 " Hg | |
| Battery Voltage | 11 volts | 18 volts |
| Closed loop fuel control | | |
| Purge Flow | 0.04 lbm/min | |
| Manifold Vacuum | 2.0 inHg | |

| **Typical Fresh Air Line Flow Check malfunction thresholds:** |
|---|
| Relative vacuum at ELCM < -20.0 inH2O / 4981.78 Pa OR<br>Absolute vacuum at ELCM > 60 inH2O / 14945.3 Pa |

| **J1979 Fresh Air Line Flow Check Mode $06 Data** | | | |
|---|---|---|---|
| Monitor ID | Comp ID | Description for CAN | Units |
| $3D | $85 | Blocked EVAP System Fresh Air Line | Pa |
| Note: Default values (0.0) will be displayed for all the above TIDs if the evap monitor has never completed. The appropriate TID will be updated based on the current or last driving cycle, default values will be displayed for any phases that have not completed. | | | |

This test is a functional check on the HEV for excessive leakage through the EVAP Switching Valve (Vapor Blocking Valve) when it is commanded closed. It runs during the flow test during engine running. This test only completes on the full hybrid. The Plug In hybrid tests the FTIV during the key off ELCM monitor.

| EVAP Switching Valve Functional Check Operation: | |
|---|---|
| DTCs | P2450 - EVAP System Switching Valve Performance/Stuck Open |
| Monitor execution | engine running, once per driving cycle |
| Monitor Sequence | P1450 not running |
| Sensors/Components OK | P0456, P0457, P24B9, P24BA, P24BB, P0100, P0102, P0103, P0106, P0107, P0108, P0720 |
| Monitoring Duration | 4 sec |

| EVAP Switching Valve Functional Check entry conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Vapor Blocking Valve (VBV) commanded closed | | |
| Air Mass | > 0 lbs/min | |
| Vehicle Speed | 0 mph | |
| Intake Air Temperature | 40 deg F | 95 deg F |
| Fuel Level | 15% | 85% |
| BARO (<8,000 ft altitude) | 22.0 " Hg | |
| Battery Voltage | 11 volts | 18 volts |
| Purge Flow | 0.08 lbm/min | |
| Manifold Vacuum | 2.0 in Hg | |
| Relative ELCM Pressure | -99 in $H_2O$ | |
| Time Since Last Abort | 20 sec | |

| Typical EVAP Switching Valve Functional Check malfunction thresholds: |
|---|
| ELCM pressure sensor rate of change during flow test > 20.0 in$H_2O$ / 4981.78 Pa |

| J1979 EVAP Switching Valve Functional Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Comp ID | Description for CAN | Units |
| $3D | $82 | Vapor Blocking Valve Performance | Pa |
| $3D | $86 | Fuel Tank Isolation Valve Stuck Open | Pa/sec |
| $3D | $87 | Fuel Tank Isolation Valve Stuck Closed | Pa/sec |
| Note: Default values (0.0) will be displayed for all the above TIDs if the evap monitor has never completed. The appropriate TID will be updated based on the current or last driving cycle, default values will be displayed for any phases that have not completed. | | | |

This is a functional check for a stuck open canister purge valve. This generates too much vacuum during the purge flow test

| EVAP Flow Check Operation: | |
|---|---|
| DTCs | P1450 - Unable to Bleed Up Fuel Tank Vacuum |
| Monitor execution | engine running, once per driving cycle |
| Monitor Sequence | |
| Sensors/Components OK | P0456, P0457, P24B9, P24BA, P24BB, P0100, P0102, P0103, P0106, P0107, P0108, P0720 |
| Monitoring Duration | 5 sec |

| EVAP Flow Check entry conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Purge Flow | | 0.0 lbm/min |
| Manifold Vacuum | 2.0 in Hg | |
| BARO (<8,000 ft altitude) | 22.0 " Hg | |
| Battery Voltage | 11 volts | 18 volts |
| FTIV or VBV commanded closed | | |
| COV commanded closed | | |

| Typical EVAP Flow Check malfunction thresholds: |
|---|
| Relative vacuum at ELCM > -10.0 in$H_2O$ / -2490.89 Pa. |

| J1979 EVAP Flow Check Functional Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Comp ID | Description for CAN | Units |
| $3D | $83 | Purge Valve Stuck Open | Pa |
| $3D | $84 | Purge Valve Stuck Closed | Pa |
| Note: Default values (0.0) will be displayed for all the above TIDs if the evap monitor has never completed. The appropriate TID will be updated based on the current or last driving cycle, default values will be displayed for any phases that have not completed. | | | |

This test is a functional check for purge flow. With Change Over Valve (COV) and purge commanded on, if not enough delta vacuum is seen by the ELCM in calibrated time then the P04ED DTC will set.

| **EVAP Large Leak Functional Check Operation:** | |
|---|---|
| DTCs | P04ED - EVAP System Large Leak Detected - Fresh Air Side |
| Monitor execution | engine running, once per driving cycle |
| Monitor Sequence | P1450 not running |
| Sensors/Components OK | P0456, P0457, P24B9, P24BA, P24BB, P0100, P0102, P0103, P0106, P0107, P0108, P0720 |
| Monitoring Duration | 4 seconds |

| **EVAP Large Leak Functional Check entry conditions** | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Vapor Blocking Valve (VBV) commanded closed | | |
| Air Mass | > 0 lbs/min | |
| Vehicle Speed | 0 mph | |
| Intake Air Temperature | 20 deg F | 95 deg F |
| Fuel Level | 15% | 85% |
| BARO (<8,000 ft altitude) | 22.0 “ Hg | |
| Battery Voltage | 11 volts | 18 volts |
| Purge Flow | 0.08 lbm/min | |
| Manifold Vacuum | 2.0 in Hg | |
| Relative ELCM Pressure | -99 in $H_2O$ | |
| Time Since Last Abort | 20 sec | |

| **Typical EVAP Large Leak Functional Check malfunction thresholds:** |
|---|
| Relative vacuum at ELCM < 8.0 in$H_2O$ / < 1992.71 Pa for > 4 seconds. |

| **J1979 EVAP Flow Check Functional Mode $06 Data** | | | |
|---|---|---|---|
| Monitor ID | Comp ID | Description for CAN | Units |
| $3D | $83 | Purge Valve Stuck Open | Pa |
| $3D | $84 | Purge Valve Stuck Closed | Pa |
| Note: Default values (0.0) will be displayed for all the above TIDs if the evap monitor has never completed. The appropriate TID will be updated based on the current or last driving cycle, default values will be displayed for any phases that have not completed. | | | |

## ELCM Leak Detection 0.020" Monitor Entry Conditions

Engine Off and Key Off (After-run) Diagnostics, consisting of:
- The 0.020" leak check
- All other EVAP system and component diagnostics are executed during the engine off period.

Note: there is a "Wait" period after key-off to ensure that ELCM pump temperature is within the specified operating temperature. The "Wait" time is a function of ambient temperature (5 – 17 min).

The entry conditions for the engine off monitor are evaluated while the vehicle is being driven, prior to shut down. Basic entry conditions for the leak diagnostics are a combination of conditions mandated by CARB and others intended to make the monitor robust to false calls.

### Phase 0: BARO Reference/ELCM Functional Tests

The first phase starts by obtaining a BARO reading. The PCM opens the CPV and vents any trapped vacuum. After some stabilization time, with all the ELCM actuators in their unpowered state, the monitor obtains a BARO reading.

Then the ELCM pump is turned on (COV not energized) to send flow through the reference orifice. If the slope of the ELCMPS pressure is less than a threshold value, then the monitor tentatively infers that the COV is stuck in the energized state and flow is not going through the reference orifice. This will set a P24C0 unless the pump functional test fails later in the test. Once the COV functional test is complete, the orifice functional test is performed. The stabilized ELCMPS pressure is compared to a threshold value to see if too much vacuum was produced. This would be an indication of a clogged/restricted orifice. In this case, the monitor aborts and a P043E DTC is set. The stabilized ELCMPS pressure is compared to a threshold value to see if too little vacuum was produced. This would be an indication of a high flow orifice. In this case, the monitor aborts and a P043F DTC is set. The last part of Phase 0 is the pump warm-up time (typically 5 min). Once the warm-up time is met, the ELCMPS pressure is compared against a threshold to determine how much vacuum was generated across the orifice during the warm-up time. Too little vacuum is an indication that the pump is stuck off in which case the monitor aborts and sets P2401 DTC. If all tests pass, monitor goes on to Phase 1.

Note: The ELCMPS sensor is an absolute sensor whereas the HPFTPT is a relative sensor. To compare the two sensors, the ELCMPS signal is converted to gauge by subtracting the BARO reading.

### Phase 1: 1st Reference Pressure Measurement

In Phase 1, the resulting ELCMPS relative pressure is averaged and stored as a 0.020" reference. This 1st reference check is compared against a table of min and max reference pressures as a function of BARO. If the reference pressure is outside the min and max, the monitor aborts and sets a P24B9 DTC. Then, the vacuum pump is commanded off and the ELCMPS pressure is compared to atmospheric pressure. If the ELCMPS pressure does not go back up above a threshold pressure, the monitor infers that the vacuum pump is stuck on, aborts and sets a P2402 DTC. Otherwise, the monitor continues on with the next phase.

### Phase 2: Vacuum Pull/Leak Detection

Phase 2 is the most critical phase in the ELCM monitor. This is where the Evap system (canister side only or the entire system) is evacuated using the ELCM vacuum pump. The COV as well as the vacuum pump are turned on. The COV stuck functional test is performed again to check whether the COV is stuck in the de-energized position. The rate of change of the ELCMPS pressure is compared to a threshold. The monitor aborts and set a P24C1 DTC if the ELCMPS vacuum slope is too high. If the COV test passes, the monitor goes on to check the FTIV valve for being stuck open. The rate of change of the ELCMPS pressure is calculated again and compared to a threshold. If the slope is too low, the FTIV is inferred to be stuck open and the monitor aborts and sets a P2450 DTC. If the FTIV had been commanded open and the rate of change of the ELCMPS pressure is greater than a threshold, then the FTIV is inferred to be stuck closed and the monitor aborts and sets a P2451 DTC.

Once the functional tests are complete, the monitor goes on perform the leak check using the averaged, stabilized pressure. Leak test results are normalized to the reference pressure obtained in Phase 1. A normalized pressure greater than the 0.020" leak threshold (> 1.0) is a pass. For HEV, the test goes on to Phase 5. For PHEV, the test goes on to Phase 3

The monitor periodically computes the slope of the pressure value. If the slope indicates that the signal is "flat lining" without crossing the reference check threshold, the determination is that a leak is present, pending the vapor generation analysis. If the signal "flat lines" for an HEV, the monitor sets a preliminary P0456 failure flag and goes to Phase 5. For a PHEV, if the signal “flat lines”, the monitor sets a preliminary P04EF failure flag indicating a leak on the fresh air side of the Evap system and the test goes on to Phase 3.

**Phase 3: Tank Pressure Evaluation (PHEV only, sealed evap system)**

In Phase 3, the filtered tank pressure is evaluated to determine whether the tank is leak-free or not. If there is sufficient pressure or vacuum buildup in the tank and the pressure/vacuum variation in the tank is low, the tank is properly sealed and there are no leaks. In such a case, the FTIV is left in its normally closed position and only the canister side of the Evap system is monitored for leaks. If the tank pressure/vacuum is near atmosphere or if the tank pressure/vacuum is high but has considerable variation, then the FTIV is commanded open and the entire Evap system is monitored for leaks. The monitor goes back to phase 2 to evacuate the entire Evap system.

If the monitor fails with the FTIV open, a fail flag is set to indicate a potential leak in the entire Evap system (P04EE).

There are no abort conditions in this phase. Note that there is a delay to allow the pressure to stabilize to atmospheric pressure between the tank and canister side checks.

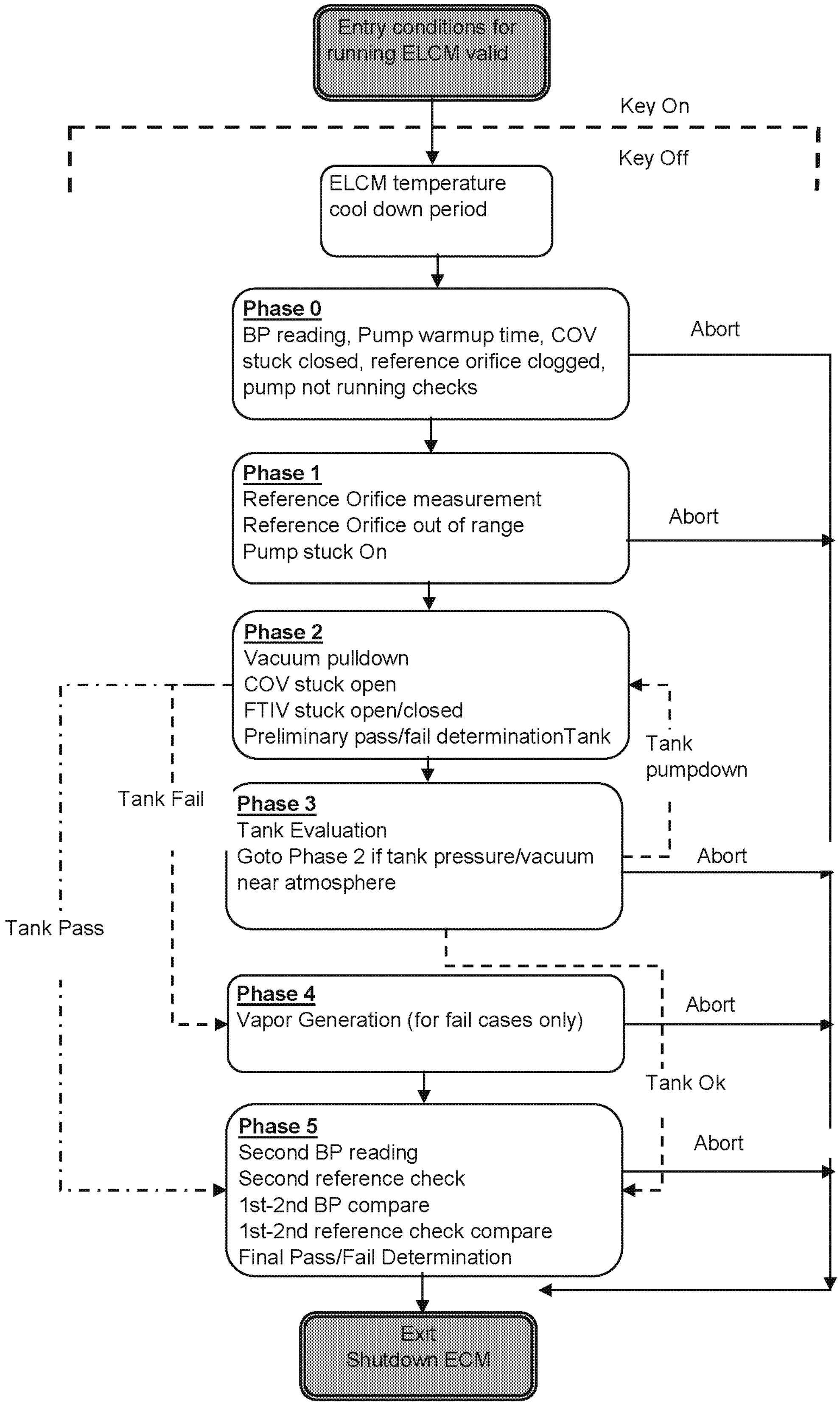
**Phase 4: Vapor Generation/CPV Stuck Closed (PHEV only, seal evap system)**

This is the phase where the full Evap system is diagnosed for vapor generation in the case where a failure occurred in the second Phase 2 while the FTIV was open. Vapor generation for the fuel results in a positive pressure build up. It is typically caused by high RVP fuels and/or hot weather. The positive pressure can overwhelm the vacuum being generated by the low flow ELCM pump. Depending on the magnitude of the vapors, an otherwise sealed Evap system could be diagnosed as having a leak; therefore, the vapor generation check is needed to qualify any leak monitor fail calls.

The vapor generation routine is based on the ideal gas law. The temperature is assumed to be constant during the duration of the test. The volume is also assumed constant since the PHEV evap system uses a rigid, metal fuel tank. Any pressure change is, therefore, due to fuel vapors. Phase 4 starts out by turning off the vacuum pump and commands the COV to its vent position. With the FTIV open, the system is allowed to vent to atmosphere until the pressure climbs to near atmosphere or times out. In the case of a timeout, the tank is assumed to have intense vapors whereby even when it is open to atmosphere, the pressure is unable to equalize with atmospheric pressure. Once the vented tank pressure is close to atmosphere, the FTIV is closed and the tank is sealed for a calibrated time period. A positive pressure buildup more than a threshold value results in an abort and discarding the fail call (i.e. a "no call"). In the case of a "pass" call in phase 2, the vapor generation test is not run.

**Phase 5: 2nd Reference Pressure Measurement**

This is the final phase in the ELCM monitor. The purpose of this phase is to validate that the 1st reference check is accurate by obtaining a 2nd reference check and comparing the two. After some stabilization time, another BARO reading is obtained and compared to the first BARO reading. If the BARO readings do not match within a calibrated limit, the monitor aborts. If the BARO readings are consistent, the monitor continues by turning on the vacuum pump for a calibrated warm-up time. The 2$^{nd}$ reference check is compared against a table of min and max reference pressures as a function of BARO. If the reference pressure is outside the min and max, the monitor aborts and sets a P24B9 DTC. If the reference check is OK, then the 1st and 2nd reference checks are compared to each other. If they disagree by more than a calibrated limit, then the monitor aborts and sets a P24B9 DTC. If the BARO readings and reference pressures are reliable, then any evap system failures determined previously are confirmed.


Entry conditions for running ELCM valid
Key On
Key Off
ELCM temperature cool down period
Phase 0
BP reading, Pump warmup time, COV stuck closed, reference orifice clogged, pump not running checks
Abort
Phase 1
Reference Orifice measurement
Reference Orifice out of range
Pump stuck On
Abort
Phase 2
Vacuum pulldown
COV stuck open
FTIV stuck open/closed
Preliminary pass/fail determinationTank
Tank pumpdown
Tank Fail
Phase 3
Tank Evaluation
Goto Phase 2 if tank pressure/vacuum near atmosphere
Abort
Tank Pass
Phase 4
Vapor Generation (for fail cases only)
Abort
Tank Ok
Phase 5
Second BP reading
Second reference check
1st-2nd BP compare
1st-2nd reference check compare
Final Pass/Fail Determination
Abort
Exit
Shutdown ECM

| 0.020" ELCM EVAP Monitor Operation: | |
|---|---|
| DTCs | P0456 – EVAP System Very Small Leak Detected (HEV)<br>P0457 – EVAP System Leak Detected (fuel cap loose/off) (HEV/PHEV)<br>P04EE - EVAP System Very Small Leak Detected - Fuel Tank Side (PHEV)<br>P04EF - EVAP System Very Small Leak Detected - Fresh Air Side (PHEV) |
| Monitor execution | Once per key-off when entry conditions are met during drive. |
| Monitor Sequence | none |
| Sensors/Components OK | P0443, P2418, P24BE, P24BF, P2401, P2402, P144B, P04ED, P1450, P24BA, P24BB, P0451, P0452, P0453, P0454, P2610, P0112, P0113, P043E, P043F, P24C0, P24C1, P2450, P2451 |
| Monitoring Duration | 45 minutes in key-off state if fault present. |

| Typical 0.020" EONV EVAP monitor entry conditions: | | |
|---|---|---|
| Entry conditions seen just prior to engine off | Minimum | Maximum |
| ELCM 24 hour run time | | 60 min |
| Time Since Pump ran | 180 minutes | |
| Ambient Temperature | 40 $^{o}$F | 95 $^{o}$F |
| Battery Voltage | 11 volts | 16 volts |
| Engine Speed | | 1 rpm |
| Vehicle Speed | | 0.1 mph |
| Fuel level | 15% | 85% |
| Not a refueling event | | |
| BARO | 22 in Hg | |
| Accumulated Aar mass flow summation | | 1000000000 lbm/min |
| Delay period in afterrun | 5 min | 17 min |
| Too much time in afterrun | | 2300 sec for HEV, 2485 sec for PHEV |

| Typical 0.020" ELCM EVAP key-off abort conditions: |
|---|
| Tank pressure > 0.8 " $H_20$ during the 5 minute key-off stabilization phase (indicates excessive vapor) |

| Typical 0.020 ELCM EVAP monitor malfunction thresholds: |
| --- |
| P0456: (0.020” leak): normalized pressure threshold (relative to reference pressure) < 1.0<br>AND<br>rate of change of pressure "flat lining" without crossing reference pressure; > 0.0 $inH_2O$/sec / 0.0 Pa/sec.<br>AND<br>Phase 2 monitor timeout without crossing reference pressure; > 800 sec for full Evap system, 100 sec for fresh air side of PHEV<br>P0457: same as P0456 except that previous driving cycle had a refueling event |

| J1979 EONV 0.020" EVAP monitor Mode $06 Data | | | |
| --- | --- | --- | --- |
| Monitor ID | Comp ID | Description for CAN | Units |
| $3C | $84 | Phase 3 stabilized leak check - Fuel Tank Side. | Pa |
| $3C | $85 | Phase 3 stabilized leak check - Fresh Air Side | Pa |
| $3C | $86 | ELCM Change-Over-Valve Stuck Open OFF (De-energized state) | Pa/sec |
| $3C | $87 | ELCM Change-Over-Valve Stuck Closed ON (Energized state) | Pa/sec |
| $3C | $88 | ELCM Pump Stuck Off | Pa |
| $3C | $89 | ELCM Pump Stuck On | Pa |
| $3C | $8A | ELCM Reference Orifice - Clogged, High Flow | Pa |
| $3C | $8B | ELCM Reference Orifice - Large size, Low Flow | Pa |
| $3C | $8D | ELCM Reference Pressure Out-of-Range | Pa |
| Note: Default values (0.0) will be displayed for all the above TIDs if the evap monitor has never completed. The appropriate TID will be updated based on the current or last driving cycle, default values will be displayed for any phases that have not completed. | | | |

## EVAP System Monitor Engine Off Component Checks

Additional malfunctions that are identified as part of the evaporative system integrity check are as follows:

The **Canister Purge Valve (CPV)** output circuit is checked for opens and shorts (P0443)

Note that a stuck closed CPV generates a P04ED, a leaking or stuck open CPV generates a P1450.

| Canister Purge Valve Circuit Check Operation: | |
|---|---|
| DTCs | P0443 – Evaporative Emission System Purge Control Valve "A" Circuit |
| Monitor execution | engine off, continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to obtain smart driver status |

| Typical Canister Purge Valve Circuit Check malfunction thresholds: |
|---|
| P0443: open/shorted |

The **Evap Fuel Tank Switching Valve** (EVAPSV) control circuit is checked for opens and shorts (P2418). For the PHEV, this component is the FTIV (Fuel Tank Isolation Valve). For the HEV, this component is the VBV (Vapor Blocking Valve).

Note that a stuck closed Evap Switching Valve generates a P2451; a stuck open Evap Switching Valve generates a P2450.

| Evap Switching Valve Check Operation: | |
|---|---|
| DTCs | P2418 - Evap Switching Valve Circuit |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to obtain smart driver status |

| Evap Switching Valve check malfunction thresholds: |
|---|
| P2418 (Evap Switching Valve Circuit): open/shorted |

The **ELCM Leak Detection Pump Control Circuit** is checked for opens and shorts and functionally.

| **ELCM Pump Control Check Operation:** | |
|---|---|
| DTCs | P2401 - EVAP System Leak Detection Pump Control Circuit Low<br>P2402 - EVAP System Leak Detection Pump Control Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to obtain smart driver status |

| **Typical ELCM Pump Control check malfunction thresholds:** |
|---|
| P2401/P2402 - output driver open/shorted |

| **ELCM Pump Control Functional Check Operation:** | |
|---|---|
| DTCs | P2401 - EVAP System Leak Detection Pump Control Circuit Low<br>P2402 - EVAP System Leak Detection Pump Control Circuit High |
| Monitor execution | during Phase 0 of evap monitor leak check |
| Monitor Sequence | Evap monitor leak detection condition met |
| Sensors OK | not applicable |
| Monitoring Duration | 360 seconds in Phase 0, 5 seconds on Phase 1 |

| **Typical ELCM Pump Control Functional Check malfunction thresholds:** |
|---|
| P2401: pressure at the end of 360 sec of warm-up time in Phase 0 too low; > -2.0 in$H_2O$ / -498.18 Pa.<br>P2402: pressure increasing in Phase 1 after pump shut off for 5 sec; > 4.0 in$H_2O$ / 996.35 Pa. |

| **ELCM Pump Control Flow Check Operation:** | |
|---|---|
| DTCs | P043E - EVAP System Leak Detection Reference Orifice Low Flow<br>P043F - EVAP System Leak Detection Reference Orifice High Flow |
| Monitor execution | once per key off, after entry conditions have been met during pre-key off drive cycle |
| Monitor Sequence | during Phase 0 of evap monitor leak check |
| Sensors OK | not applicable |
| Monitoring Duration | 60 seconds in Phase 0 |

| **Typical ELCM Pump Control flow check malfunction thresholds:** |
|---|
| P043E: stabilized pressure at the end of Phase 0 too low <= -20.2 in$H_2O$ / 5031.6 Pa<br>P043F: stabilized pressure at the end of Phase 0 too high > -2.8 in$H_2O$ / > -697.45 Pa. |

The **Evap Leak Detection Pump Vacuum Switching Valve / (Change Over Valve)** control circuit is checked for opens and shorts and functionally.

| **Evap Vacuum Switching Valve Circuit Check Operation:** | |
|---|---|
| DTCs | P24BE - EVAP Leak Detection Pump Vacuum Switching Valve Control Circuit Low<br>P24BF - EVAP Leak Detection Pump Vacuum Switching Valve Control Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to obtain smart driver status |

| **Evap Vacuum Switching Valve Circuit Check malfunction thresholds:** |
|---|
| P24BE/P24BF - output driver open/shorted |

| **Evap Vacuum Switching Valve Functional Check Operation:** | |
|---|---|
| DTCs | P24C0 - EVAP System Leak Detection Pump Vacuum Switching Valve Stuck On<br>P24C1 - EVAP System Leak Detection Pump Vacuum Switching Valve Performance/Stuck Off |
| Monitor execution | P24C0 during Phase 0 of evap monitor leak check, P24C1 during Phase 2 of evap monitor leak check |
| Monitor Sequence | Evap monitor leak detection condition met |
| Sensors OK | P0443, P2418, P24BE, P24BF, P2401, P2402, P144B, P04ED, P1450, P24BA, P24BB, P0451, P0452, P0453, P0454, P2610, P0112, P0113, P043E, P043F, P24C0, P24C1, P2450, P2451 |
| Monitoring Duration | 65 seconds in Phase 0, 2 seconds in Phase 2 |

| **Evap Vacuum Switching Valve check malfunction thresholds:** |
|---|
| P24C0: rate of change of pressure too low; < 1.2 in$H_2O$ / 174.36 Pa |
| P24C1: rate of change of pressure too high; > 4.0 inH2O / 996.35 Pa. |

The **EVAP System Leak Detection Pump Pressure Sensor** input circuit is checked for opens and shorts, out of range values and noisy readings.

| Leak Detection Pump Pressure Sensor Check Operation: | |
|---|---|
| DTCs | P24BA - EVAP System Leak Detection Pump Pressure Sensor Circuit Low<br>P24BB - EVAP System Leak Detection Pump Pressure Sensor Circuit High<br>P24B9 - EVAP System Leak Detection Pump Pressure Sensor Circuit Range/Performance<br>P24BC - EVAP System Leak Detection Pump Pressure Sensor Circuit Intermittent (noisy) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 20 seconds for electrical malfunctions, 10 seconds for noisy sensor test |

| Typical Leak Detection Pump Pressure Sensor check malfunction thresholds: |
|---|
| P24BA (Circuit low): < 168.96 $inH_20$ / 42.08 kPa. |
| P0453 (Circuit high): > 496.93 $inH_20$ / 123.78 kPa. |
| P24B9 (Reference out of range) > -1.5 to -5.5 in $H_2O$ (function of BARO) OR<br>< -17.5 to -21.5 in $H_2O$ (function of BARO) |
| P24BC (noisy): open circuit, short circuit or > 25.0 $inH_2O$ / 6.227 kPa change between samples, sampled every 100 milliseconds, filtered fault level of 25% will set code in 10 seconds |

The **Fuel Tank Pressure Sensor** input circuit is checked for out of range values (P0452 short, P0453 open), noisy readings (P0454 noisy) and an offset (P0451 offset).

Note that for the PHEV, this component is the FTPTHP (Fuel Tank Pressure Transducer – High Pressure). For the HEV, this component is the FTPT (Fuel Tank Pressure Transducer).

| **Fuel Tank Pressure Sensor Transfer Function** | | |
|---|---|---|
| FTP volts = [ Vref * ( 0.14167 * Tank Pressure) + 2.6250 ] / 5.00 | | |
| Volts | A/D Counts in PCM | Fuel Tank Pressure, Inches $H_2O$ |
| 0.100 | 20 | -17.82 |
| 0.500 | 102 | -15.0 |
| 1.208 | 247 | -10.0 |
| 2.625 | 464 | 0 |
| 3.475. | 712 | 6.0 |
| 4.750 | 973 | 15.0 |
| 4.90 | 1004 | 16.06 |

| **High Pressure Fuel Tank Pressure Sensor Transfer Function** | | |
|---|---|---|
| FTP volts = [ Vref * ( 0.015 * Pump Pressure) + 1.15 ] / 5.00 | | |
| Volts | A/D Counts in PCM | Fuel Tank Pressure, Inches $H_2O$ |
| 0.25 | 51 | -60.0 |
| 0.50 | 102 | -43.33 |
| 1.15 | 235 | 0.00 |
| 2.05 | 419 | 60.00 |
| 3.00 | 614 | 123.33 |
| 4.50 | 921 | 223.33 |
| 4.75 | 970 | 240.0 |

| **Fuel Tank Pressure Sensor Check Operation:** | |
|---|---|
| DTCs | P0452 – Fuel Tank Pressure Sensor Circuit Low<br>P0453 – Fuel Tank Pressure Sensor Circuit High<br>P0454 – Fuel Tank Pressure Sensor Intermittent/Erratic (noisy) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds for electrical malfunctions, 10 seconds for noisy sensor test |

| Typical Fuel Tank Pressure Sensor check malfunction thresholds: |
|---|
| P0452 (Fuel Tank Pressure Sensor Circuit Low): < -17.82 in $H_2O$ |
| P0452 (High Pressure Fuel Tank Pressure Sensor Circuit Low): < -60.00 in $H_2O$ |
| P0453 (Fuel Tank Pressure Sensor Circuit High): > 16.06 in $H_2O$ |
| P0453 (High PressureFuel Tank Pressure Sensor Circuit High): > 2401.00 in H2O |
| P0454 (Fuel Tank Pressure Sensor Circuit Noisy): open circuit, short circuit or > 25 in $H_2O$ change between samples, sampled every 100 milliseconds, filtered fault level of 25% will set code in 10 seconds |

| Fuel Tank Pressures Sensor Offset Check Operation | |
|---|---|
| DTCs | P0451 – Fuel Tank Pressure Sensor Range/Performance (offset) |
| Monitor execution | once per driving cycle |
| Monitor Sequence | No P0443 or P1450 DTCs |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 second |

| Typical Fuel Tank Pressure Sensor Offset Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Ignition key on, engine off, engine rpm | | 0 rpm |
| Purge Duty Cycle | | 0% |
| Engine off (soak) time | 240 min | |
| Fuel Tank Pressure Sensor Variation during test | | 0.5 in $H_2O$ |
| Battery Voltage | 11.0 Volts | |

| Typical Fuel Tank Pressure Sensor Offset Check Malfunction Thresholds: |
|---|
| Fuel tank pressure at key on, engine off is 0.0 in $H_2O$ +/- 1.7 in $H_2O$ |

The **Fuel Level Input** is checked for out of range values (opens/ shorts). The FLI input is obtained from the serial data link from the instrument cluster. If the FLI signal is open or shorted, the appropriate DTC is set, (P0462 circuit low and P0463 circuit high).

Finally, the Fuel Level Input is checked for noisy readings. If the FLI input changes from an in-range to out-of-range value repeatedly, a P0461 DTC is set.

| **Fuel Level Input Check Operation:** | |
|---|---|
| DTCs | P0460 – Fuel Level Sensor A Circuit<br>P0461 – Fuel Level Sensor A Circuit Noisy<br>P0462 – Fuel Level Sensor A Circuit Low<br>P0463 – Fuel Level Sensor A Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 30 seconds for electrical malfunctions |

| **Typical Fuel Level Input check malfunction thresholds:** |
|---|
| P0460 or P0462 (Fuel Level Input Circuit Low): < 5 ohms (< 1 A/D count) |
| P0460 or P0463 (Fuel Level Input Circuit High): > 200 ohms (>1022 A/D counts) |
| P0461 (Fuel Level Input Noisy): > 40% change between samples, > 100 occurrences, sampled every 0.100 seconds |

The FLI signal is also checked to determine if it is stuck. "Fuel consumed" is continuously calculated based on PCM fuel pulsewidth summation as a percent of fuel tank capacity. (Fuel consumed and fuel gauge reading range are both stored in KAM and reset after a refueling event or DTC storage.) If the there is an insufficient corresponding change in fuel tank level, a P0460 DTC is set.

Different malfunction criteria are applied based on the range in which the fuel level sensor is stuck.

In the range between 6% and 93%, a 17.5% difference between fuel consumed.

In the range below 6%, a 27.5% difference between fuel consumed.

In the range above 93%, a 80.5% difference between fuel consumed.

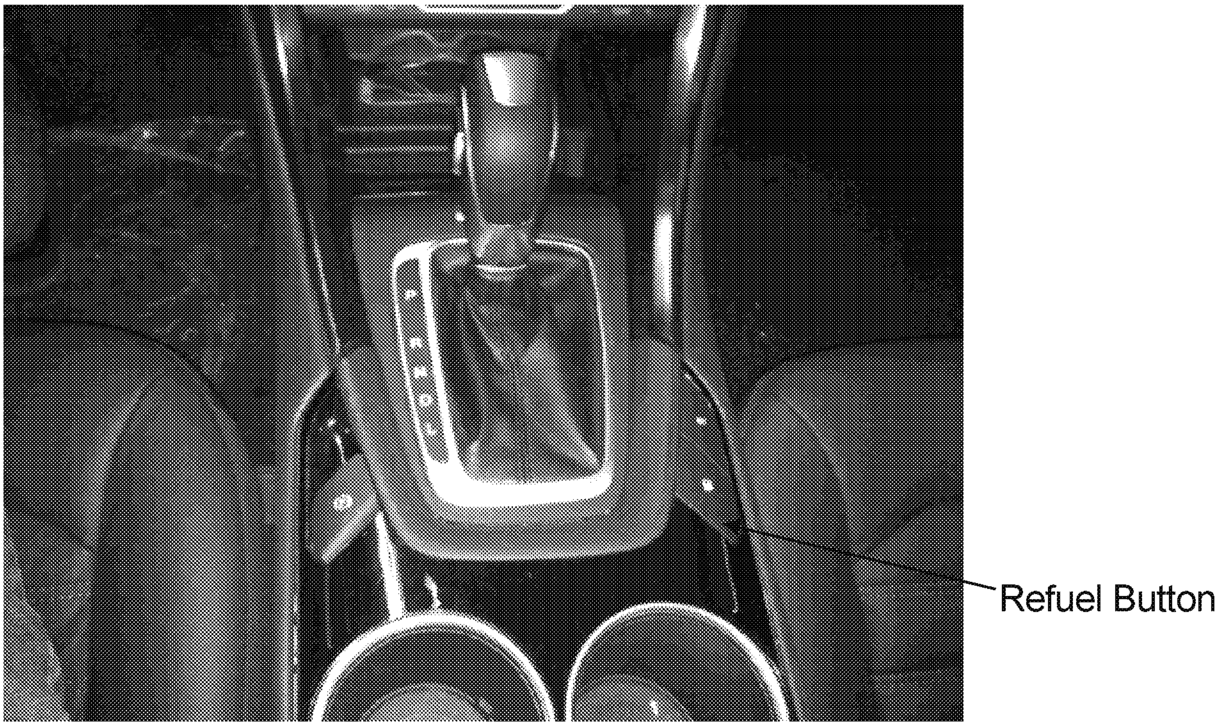
| Fuel Level Input Stuck Check Operation: | |
|---|---|
| DTCs | P0460 – Fuel Level Input Circuit Stuck |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | Between 6 and 93%, monitoring can take from100 to 120 miles to complete |

| Typical Fuel Level Input Stuck check malfunction thresholds: |
|---|
| P0460 (Fuel Level Input Stuck): |
| Fuel level stuck at greater than 93%: > 80.5% difference in calculated fuel tank capacity consumed versus change in fuel level input reading |
| Fuel level stuck at less than 6%: > 27.5% difference in calculated fuel tank capacity consumed versus change in fuel level input reading |
| Fuel level stuck between 6% and 93%: > 17.5% difference in calculated fuel tank capacity consumed versus change in fuel level input reading |

## PHEV Re-Fueling System

The PHEV uses a pressurized evap system. In order to refuel the vehicle, the customer needs to push a fuel door button in the cabin. This allows the PCM to both open a latch on the spring-loaded fuel fill door on the outside of the vehicle to provide access to the fuel filler inlet and open an FTIV (Fuel Tank Isolation Valve) which vents the evap system to the canister and allows refueling fuel vapors to enter the canister.

If the FTIV is not open, the evap system will vent when the customer pushes the fuel fill nozzle into the fuel fill inlet and the customer will not be able to refuel the vehicle because the displaced vapors have no where to go).

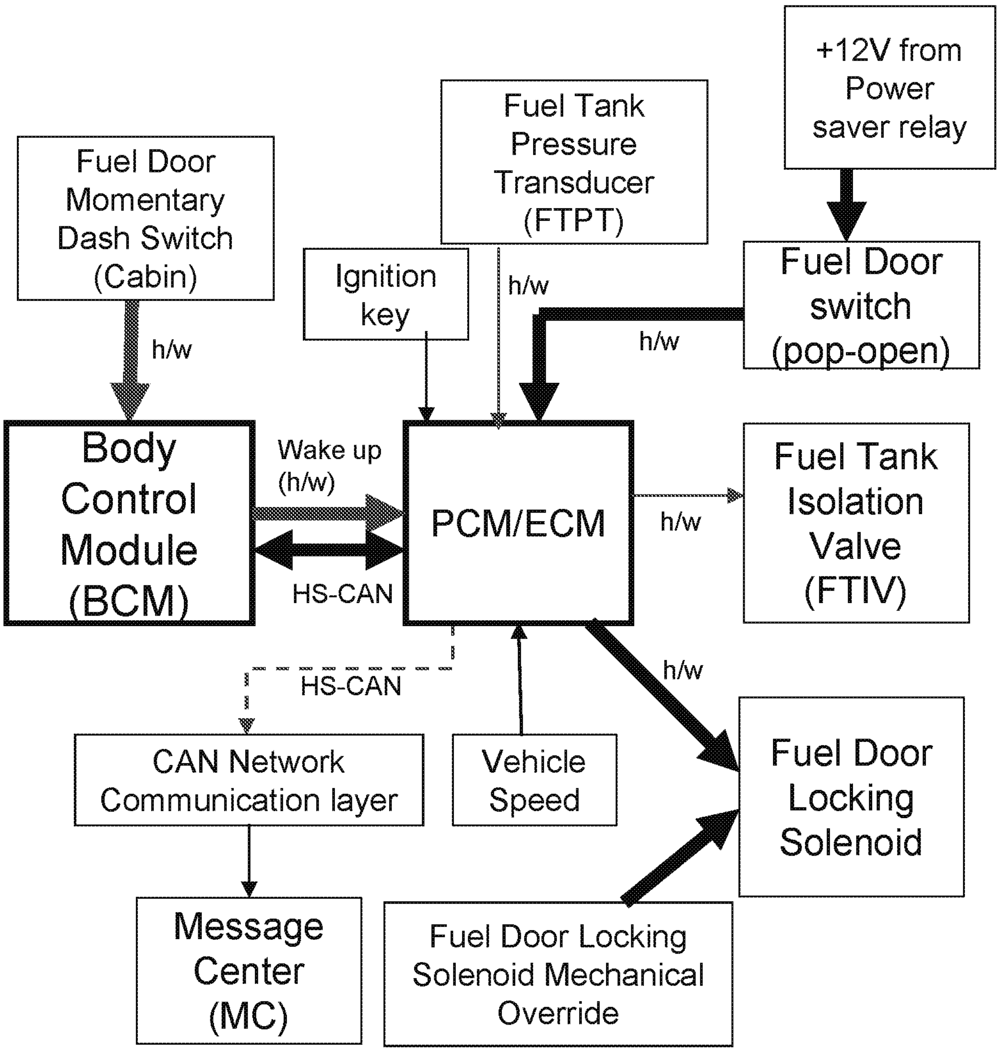



Refueling Process:

- Customer presses “refuel button”
- Signal is sent from BCM to PCM
- PCM opens FTIV & reads FTPT
- PCM sends cluster message “Please wait to refuel”
- Once fuel pressure is relieved, PCM unlocks fuel door solenoid.
- PCM sends cluster message “Ready to Refuel”
- Customer dispenses fuel
- Customer closes fuel door
- PCM recognizes closed fuel door by switch state
- FTIV closes

Mechanical Fail Safe Mode:

- Customer presses “refuel button”
- Customer activates mechanical override of locking solenoid
- PCM recognizes fuel door is open by switch position
- Continue from "Refueling Process", third item (PCM opens FTIV & reads FTPT.


+12V from Power saver relay
Fuel Tank Pressure Transducer (FTPT)
Fuel Door Momentary Dash Switch (Cabin)
Ignition key
h/w
Fuel Door switch (pop-open)
h/w
h/w
Body Control Module (BCM)
Wake up (h/w)
PCM/ECM
HS-CAN
h/w
Fuel Tank Isolation Valve (FTIV)
HS-CAN
h/w
CAN Network Communication layer
Vehicle Speed
Fuel Door Locking Solenoid
Message Center (MC)
Fuel Door Locking Solenoid Mechanical Override

The **Fuel Door Switch** is checked for opens and shorts and functionally.

| Fuel Door Switch Check Operation: | |
|---|---|
| DTCs | P04BA - Fuel Fill Door Position Sensor / Switch Circuit High<br>P04B9 - Fuel Fill Door Position Sensor / Switch Circuit Low<br>P04B5 - Fuel Fill Door Stuck Open |
| Monitor execution | continuous, engine off |
| Monitor Sequence | After refueling is requested, P04B5 after refueling is completed |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds |

| Typical Fuel Door Switch check malfunction thresholds: |
|---|
| P04BA:<br>1) Shorted to battery (door closed). Fuel door opens after unlock solenoid is energized but no indication to PCM. No indication to PCM to close FTIV after refueling. FTIV stays open longer than required. FTIV will close after timeout period.<br>2) Mechanically stuck (door closed). Fuel door opens after unlock solenoid is energized but no indication to PCM. No indication to PCM to close FTIV after refueling. FTIV stays open longer than required. FTIV will close after timeout period.<br>3) Mechanically stuck latched. Customer cannot refuel vehicle |
| P04B9:<br>1) Open circuit (door open). No indication to PCM to close FTIV after refueling. FTIV will close after timeout period.<br>2) Shorted to ground (door open). No indication to PCM to close FTIV after refueling. FTIV will close after timeout period.<br>3) Mechanically stuck unlatched. Fuel door always unlatched. Potential for fuel spit back if customer refuels without pushing cabin refuel button (not likely) |
| P04B5:<br>1) Mechanically stuck (door open) or customer did not close fuel door. No indication to close FTIV after refueling. |

The **Cabin Refuel Switch** is checked for opens and shorts and functionally.

| Cabin Refuel Switch Check Operation: | |
|---|---|
| DTCs | P04C9 - Fuel Fill Door Open Request Sensor / Switch Performance / Stuck Off.<br>P04CD - Fuel Fill Door Open Request Sensor / Switch Performance / Stuck On.<br>U0140 – Lost Communication With Body Control Module<br>U0442 – Invalid Data Received from Body Control Module |
| Monitor execution | continuous, engine off, > 5 mph for P04CD |
| Monitor Sequence | After refueling is requested |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds |

| Cabin Refuel Switch check malfunction thresholds: |
|---|
| P04C9:<br>1) Circuit shorted to battery. No request to open fuel door or FTIV. Customer cannot refuel vehicle without using manual override.<br>2) Circuit open. No request to open fuel door or FTIV. Customer cannot refuel vehicle without using manual override.<br>3) Button mechanically stuck not depressed. No request to open fuel door or FTIV. Customer cannot refuel vehicle without using manual override. |
| P04CD:<br>1) Circuit shorted to ground. Always requesting vent and fuel door unlock when vehicle is stopped and in park or neutral with park brake activated. FTIV will close after timeout period.<br>2) Button mechanically stuck depressed. Always requesting vent and fuel door unlock when vehicle is stopped and in park or neutral with park brake activated. FTIV will close after timeout period. |
| U0140/U422:<br>1) CAN message between BCM and PCM missing or invalid. No request to open fuel door or FTIV. Customer cannot refuel vehicle without using manual override. |

The **Fuel Fill Door Unlock Control Circuit** is checked for opens and shorts and functionally.

| Fuel Fill Door Unlock Control Check Operation: | |
|---|---|
| DTCs | P04C2 - Fuel Fill Door Unlock Control Circuit High<br>P04C1 - Fuel Fill Door Unlock Control Circuit Low |
| Monitor execution | continuous, engine off |
| Monitor Sequence | After refueling is requested |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds |

| Fuel Fill Door Unlock Control check malfunction thresholds: |
|---|
| P04C2:<br>1) Circuit shorted to power. (fuel door latched). Customer cannot refuel vehicle without using manual override.<br>2) Circuit open (fuel door latched). Customer cannot refuel vehicle without using manual override. |
| P04C1:<br>1) Circuit shorted to ground. (fuel door unlatched). Fuel door always unlatched. Potential for fuel spit back if customer refuels without pushing cabin refuel button (not likely) |

# Fuel System Monitor

The adaptive fuel strategy uses O2 sensors for fuel feedback. The fuel equation includes short and long term fuel trim modifiers:

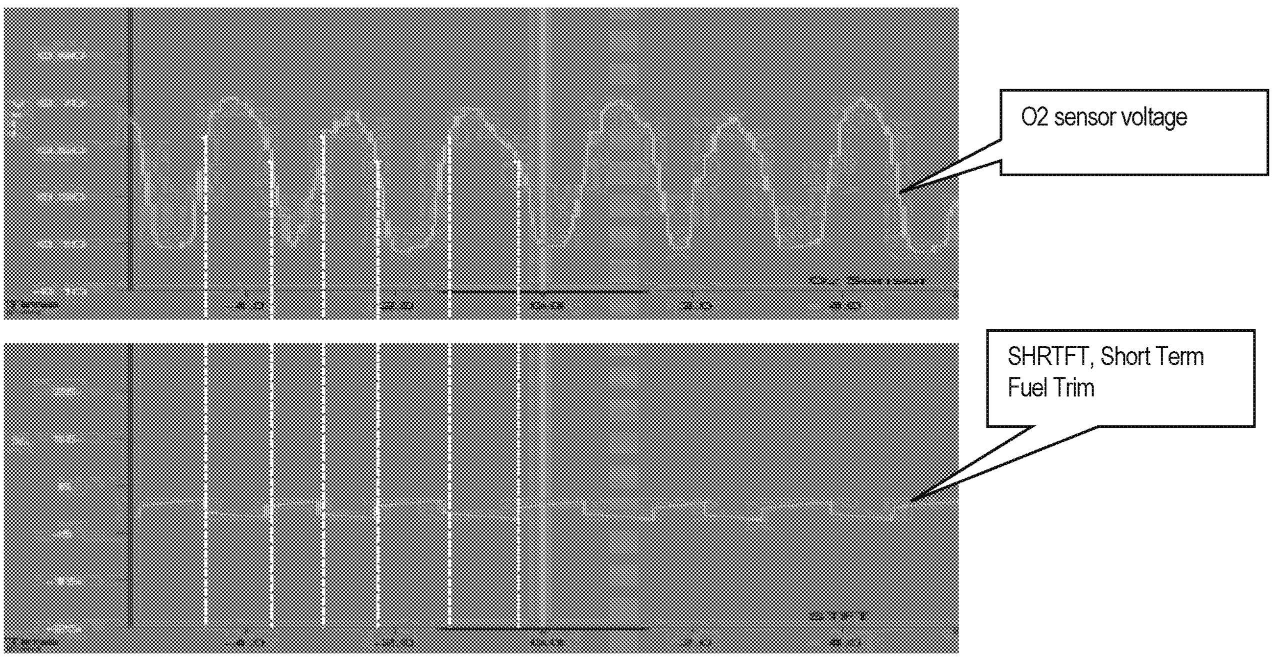
$$\text{FUEL MASS} = \frac{\text{AIR MASS} * \text{SHRTFT} * \text{LONGFT}}{\text{EQUIV\_RATIO} * 14.64}$$

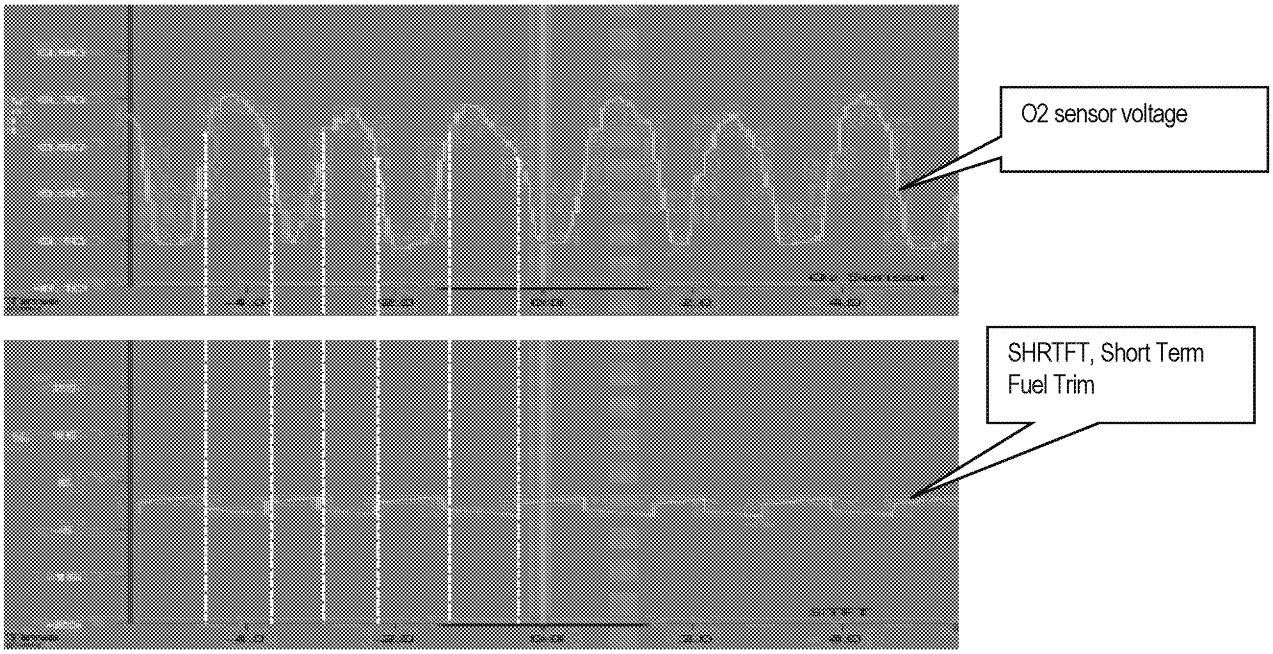
Where:

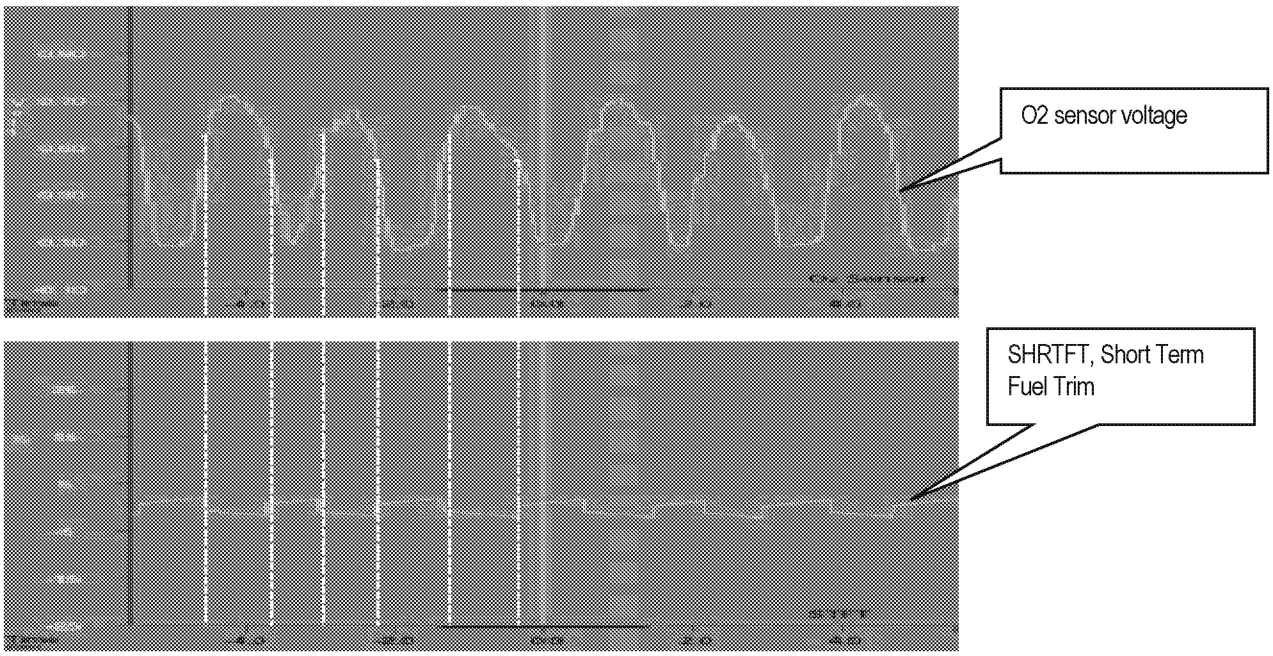
Fuel Mass = desired fuel mass
Air Mass = measured air mass, from MAF sensor
SHRTFT = Short Term Fuel Trim, calculated
LONGFT = Long Term Fuel Trim, learned table value, stored in Keep Alive Memory
EQUIV_RATIO = Desired equivalence ratio, 1.0 = stoich, > 1.0 is lean, < 1.0 is rich
14.64 = Stoichiometric ratio for gasoline

A conventional O2 sensor (not a wide-range sensor) can only indicate if the mixture is richer or leaner than stoichiometric. During closed loop operation, short term fuel trim values are calculated by the PCM using oxygen sensor inputs in order to maintain a stoichiometric air/fuel ratio. The PCM is constantly making adjustments to the short term fuel trim, which causes the oxygen sensor voltage to switch from rich to lean around the stoichiometric point. As long as the short term fuel trim is able to cause the oxygen sensor voltage to switch, a stoichiometric air/fuel ratio is maintained.

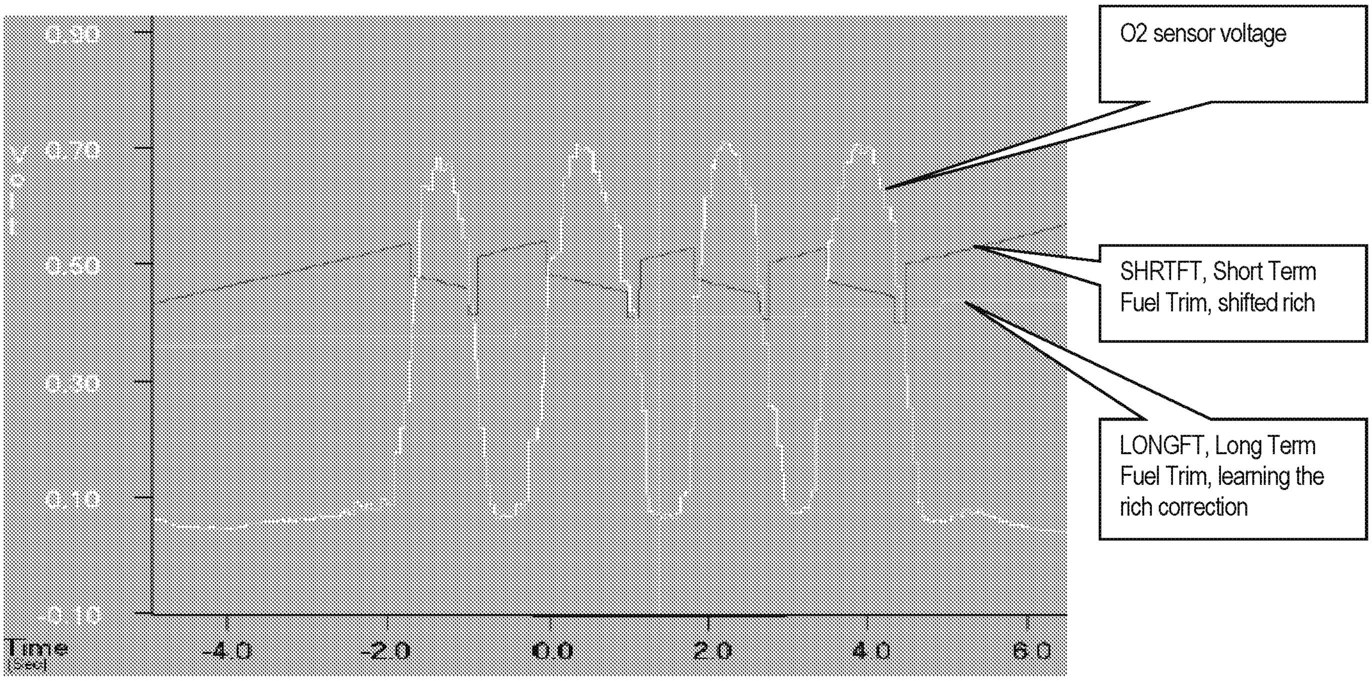
When initially entering closed loop fuel, SHRTFT starts 1.0 and begins adding or subtracting fuel in order to make the oxygen sensor switch from its current state. If the oxygen sensor signal sent to the PCM is greater than 0.45 volts, the PCM considers the mixture rich and SHRTFT shortens the injector pulse width. When the cylinder fires using the new injector pulse width, the exhaust contains more oxygen. Now when the exhaust passes the oxygen sensor, it causes the voltage to switch below 0.45 volts, the PCM considers the mixture lean, and SHRTFT lengthens the injector pulse width. This cycle continues as long as the fuel system is in closed loop operation.

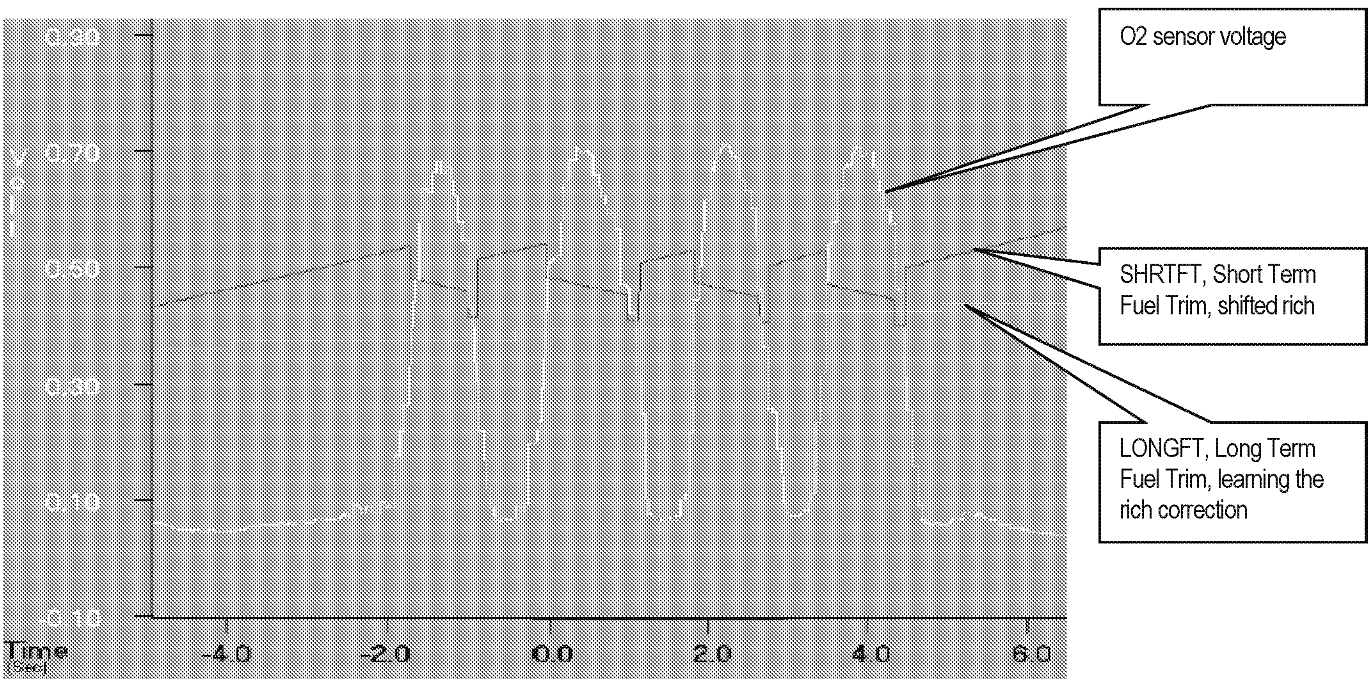



O2 sensor voltage
SHRTFT, Short Term Fuel Trim

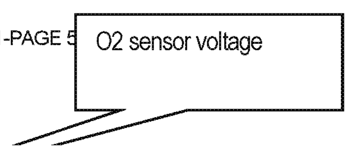

O2 sensor voltage
SHRTFT, Short Term Fuel Trim

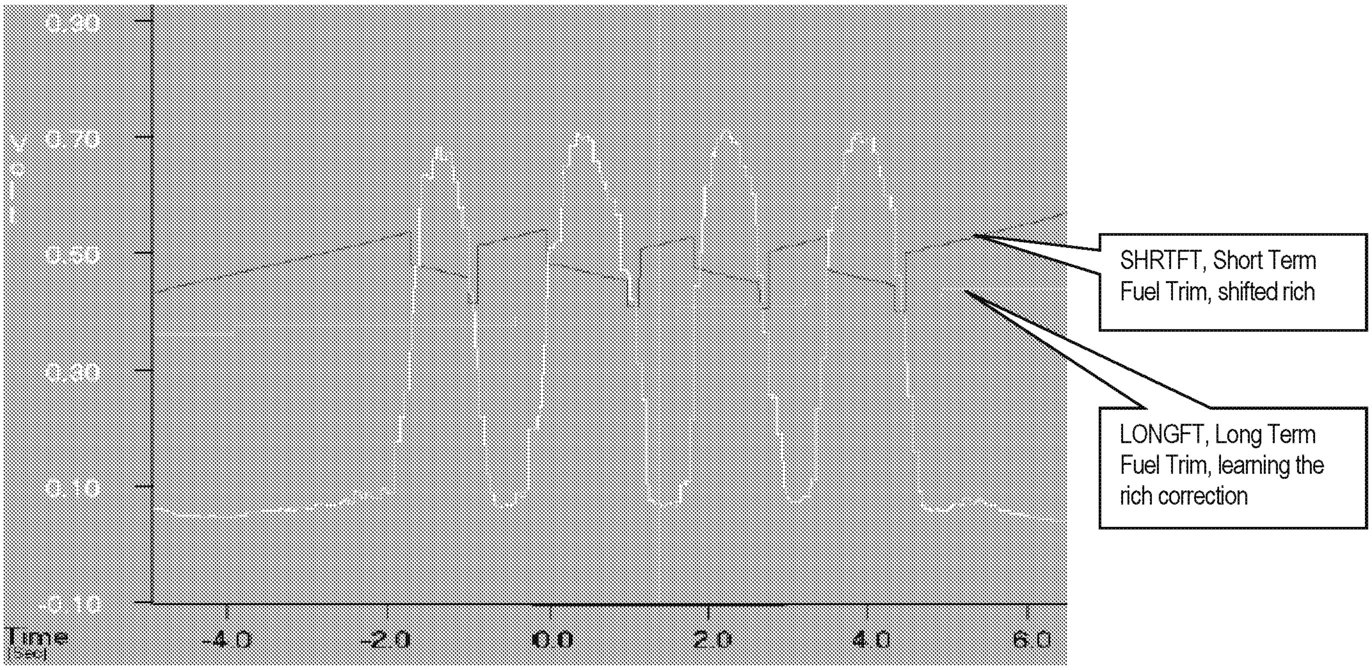
As fuel, air, or engine components age or otherwise change over the life of the vehicle, the adaptive fuel strategy learns deviations from stoichiometry while running in closed loop fuel. Corrections are only learned during closed loop operation, and are stored in the PCM as long term fuel trim values (LONGFT). They may be stored into an 8x10 rpm/load table or they may be stored as a function of air mass. LONGFT values are only learned when SHRTFT values cause the oxygen sensor to switch. If the average SHRTFT value remains above or below stoichiometry, the PCM "learns" a new LONGFT value, which allows the SHRTFT value to return to an average value near 1.0. LONGFT values are stored in Keep Alive Memory as a function of air mass. The LONGFT value displayed on the scan tool is the value being used for the current operating condition.





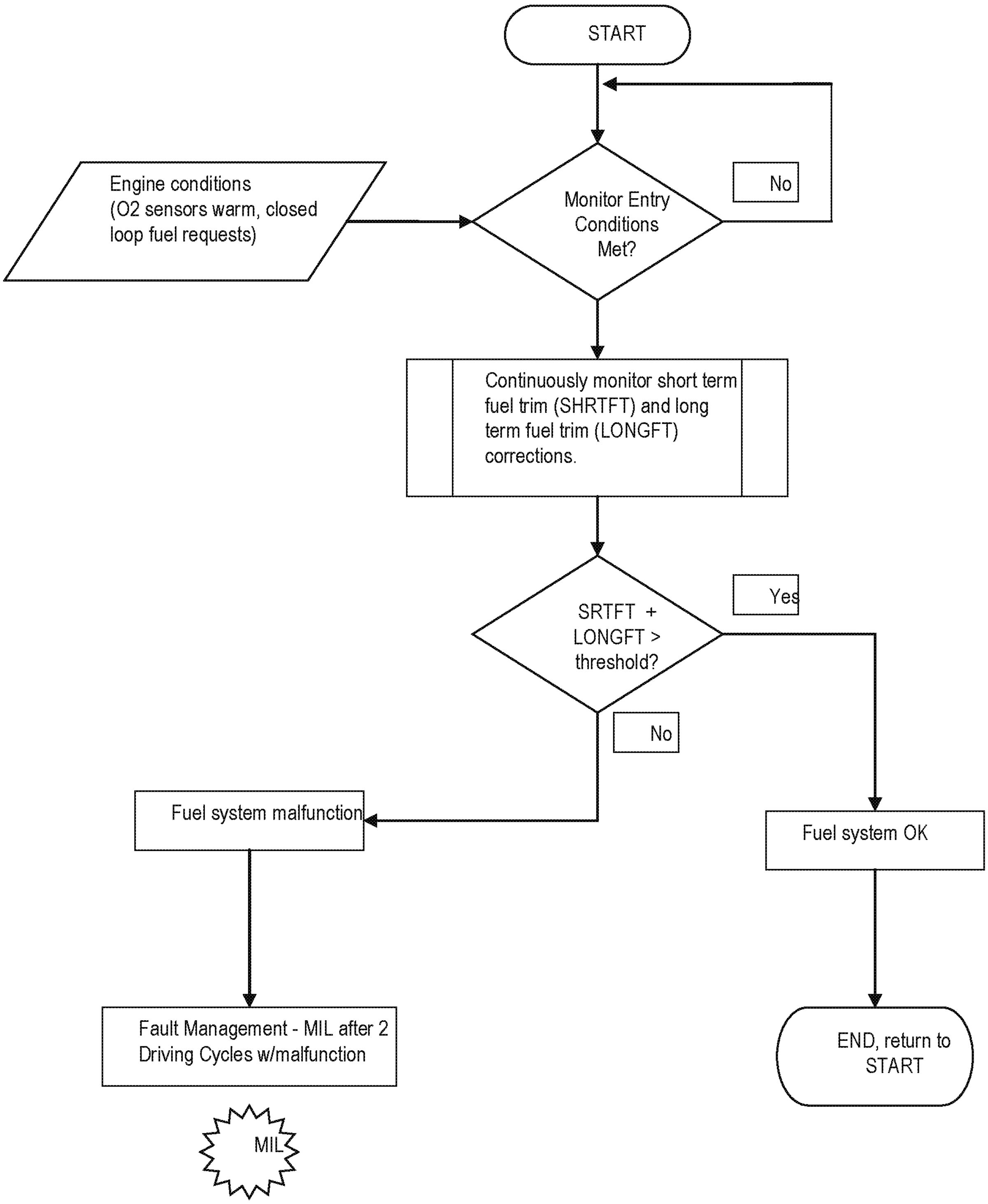






As components continue to change beyond normal limits or if a malfunction occurs, the long-term fuel trim values will reach a calibratable rich or lean limit where the adaptive fuel strategy is no longer allowed to compensate for additional fuel system changes. Long term fuel trim corrections at their limits, in conjunction with a calibratable deviation in short term fuel trim, indicate a rich or lean fuel system malfunction.

Note that in the PCM, both long and short-term fuel trim are multipliers in the fuel pulse width equation. Scan tools normally display fuel trim as percent adders. If there were no correction required, a scan tool would display 0% even though the PCM was actually using a multiplier of 1.0 in the fuel pulse width equation.

## Fuel System Monitor



| Fuel Monitor Operation: | |
|---|---|
| DTCs | P0171 Bank 1 Lean<br>P0172 Bank 1 Rich |
| Monitor execution | continuous while in closed loop fuel |
| Monitor Sequence | none |
| Sensors OK | Fuel Rail Pressure (if available), IAT, CHT/ECT, MAF, TP |
| Monitoring Duration | 2 seconds to register malfunction |

| Typical fuel monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Coolant Temp | 155 °F | 230 °F |
| Intake Air Temp | -40 °F | 150 °F |
| Engine Load | 30% | |
| Purge Duty Cycle | 0% | 0% |
| Fuel Level | 15% | |

| Typical fuel monitor malfunction thresholds: |
|---|
| Long Term Fuel Trim correction cell currently being utilized in conjunction with Short Term Fuel Trim:<br>Lean malfunction: LONGFT > 28%, SHRTFT > 2%<br>Rich malfunction: LONGFT < 24%, SHRTFT < -2% |

## FAOSC (Rear Fuel Trim) Monitor

As the front UEGO sensor ages and gets exposed to contaminants, it can develop a rich or lean bias in its transfer function. The rear bias control (also called FAOSC – Fore/Aft Oxygen Sensor Control) system is designed to compensate for any of these bias shifts (offsets) using the downstream HO2S sensor. The "FAOS" monitor looks for any bias shifts at the stoichiometric point of the front UEGO sensor lambda curve. If the UEGO has developed a bias beyond the point for which it can be compensated for, lean (P2096, P2098) or rich (P2097, P2099) fault codes will be set.

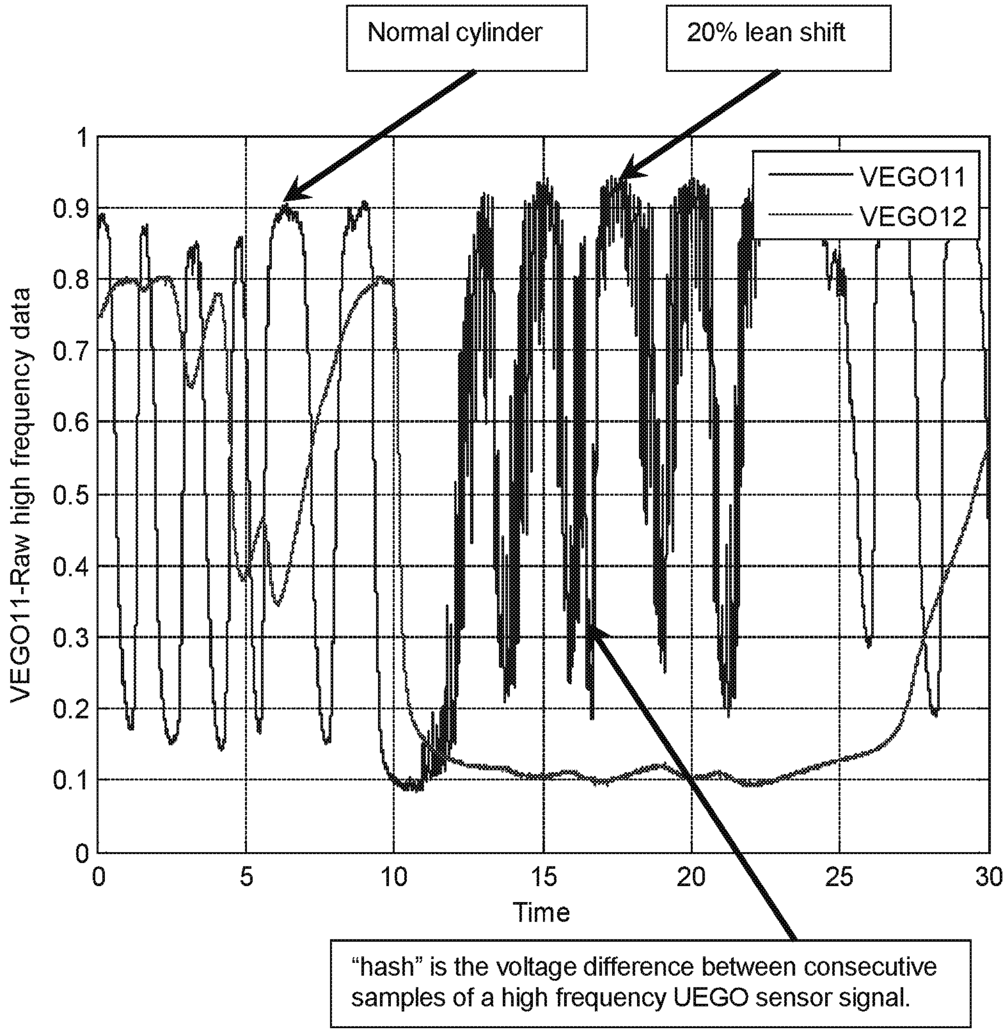
| UEGO "FAOS Monitor" Operation: | |
|---|---|
| DTCs | P2096 – Post catalyst fuel trim system too lean (Bank 1)<br>P2097 – Post catalyst fuel trim system too rich (Bank 1) |
| Monitor execution | Continuous while in closed loop fuel |
| Monitor Sequence | > 30 seconds time in lack of movement test, > 30 seconds time in lack of switch test |
| Sensors OK | ECT, IAT, MAF, MAP, VSS, TP, ETC, FRP, FVR, DPFE EGR, VCT, VMV/EVMV, CVS, CPV, EVAPSV, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, rear HO2S heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no UEGO circuit malfunction, no rear stream 2 HO2S circuit malfunction, no rear stream 2 HO2S functional DTCs, no rear stream 2 HO2S response rate malfunction. |
| Monitoring Duration | 5 seconds to register a malfunction |

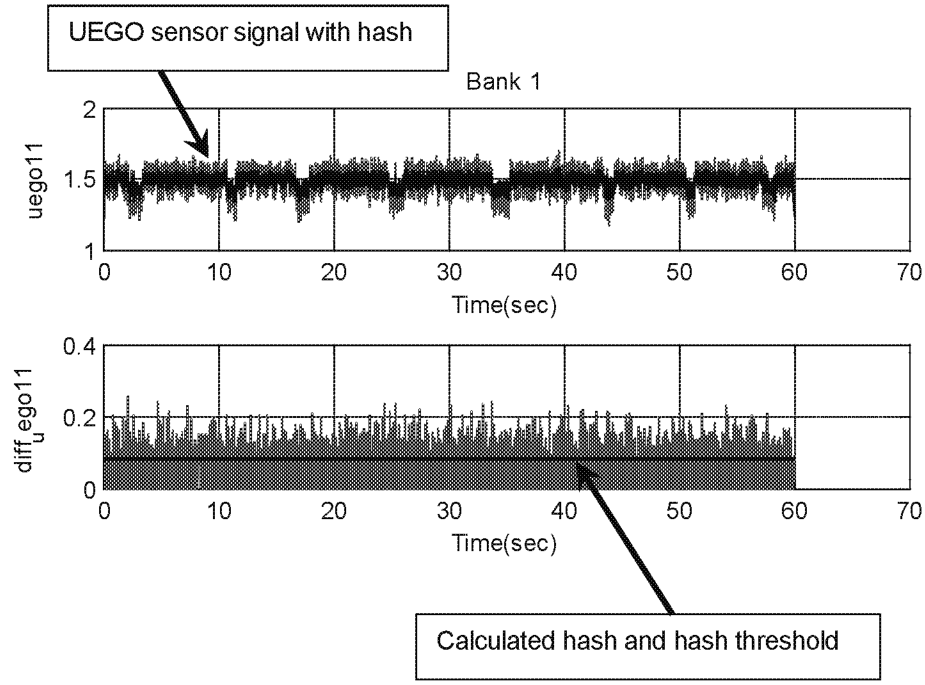
| Typical UEGO "FAOS Monitor" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed loop stoich fuel control | | |
| Time since engine start | 2 seconds | |
| Engine Coolant Temp | 150 °F | 235 °F |
| Time since entering closed loop fuel | 10 seconds | |
| Fuel Level | 15% | |
| Short Term Fuel Trim Range | -13% | 18% |
| Short Term Fuel Trim Absolute Change | | 17% |
| Air mass range | 1.5 lbm/min | 8 lbm/min |
| Learning conditions stability time (based on air mass) | 15 seconds | |
| Injector fuel pulsewidth (not at minimum clip) | 850 usec | |
| Inferred HO2S 2 Heated Tip Temperature | 800 °F | |
| No excessive movement between currently utilized long term fuel trim cells (1 = complete change from one cell to adjacent cell) | | |
| UEGO sensor within +/- 2 % from the fuel control target | | |
| UEGO ASIC not in recalibration mode | | |
| Stream1 UEGO response test not running | | |
| Intrusive UEGO catalyst monitor not running | | |
| Not performing intrusive UEGO Lack-of-Movement fuel control defib | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

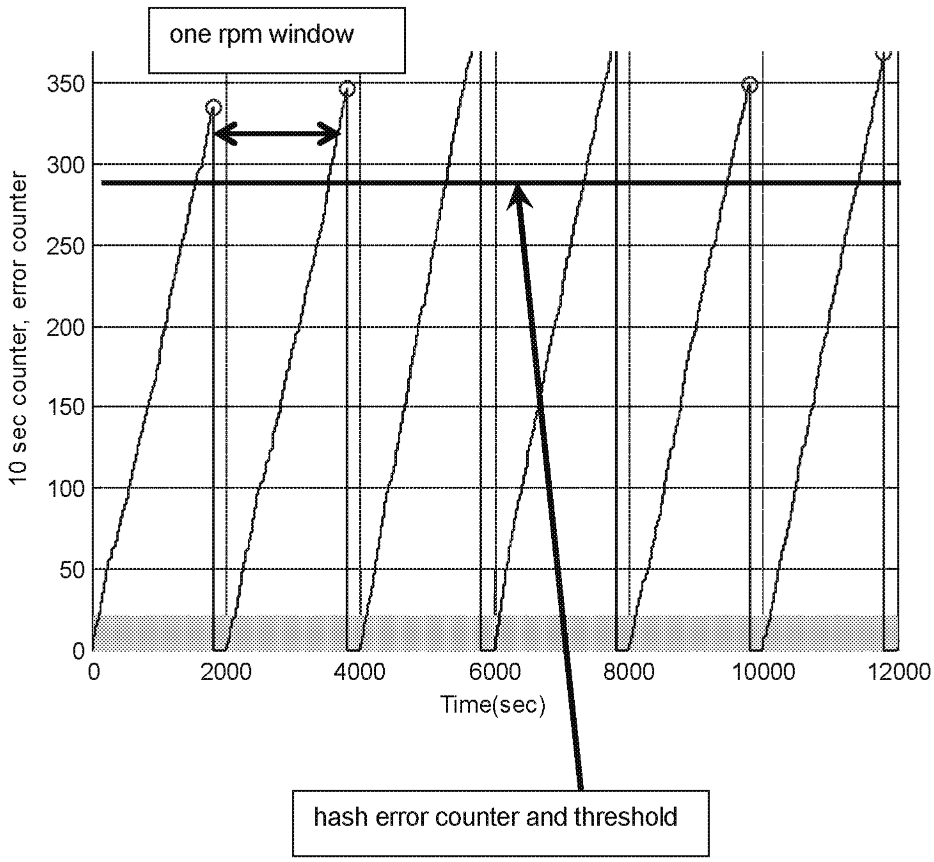
| Typical UEGO "FAOS Monitor" malfunction thresholds: |
|---|
| >= 5 seconds since reaching the FAOSC lean or rich limits while system bias maturity is met. |

## Air Fuel Ratio Imbalance Monitor

The Air Fuel Imbalance Monitor is designed to monitor the cylinder-to-cylinder air fuel imbalance per engine bank. When an Air Fuel (A/F) imbalance is present, the front UEGO signal becomes noisier. The monitor uses the high frequency component from the UEGO signal as an indicator of A/F imbalance. "Hash" is the difference between two consecutive front UEGO voltage samples. The UEGO signal is monitored continuously and a differential or "hash" value is continuously calculated. When the hash is below a threshold, it is indicative of normal operation. If the hash exceeds the threshold, an A/F imbalance is assumed which increments a hash error counter. The counter accumulates hash during series of calibratable rpm windows. Typically, a single window consists of 50 engine revolutions. A total rpm window counter calculates number of completed rpm windows. Monitor completion typically requires 30 rpm windows. When the monitor completes, an A/Fuel imbalance index is calculated. The monitor index is defined as the ratio of the failed rpm windows over the total rpm windows required to complete monitor. If the monitor imbalance ratio index exceeds the threshold value, an A/F imbalance DTC is set.




UEGO sensor signal with hash
Bank 1
uego11
2
1.5
1
0
10
20
30
40
50
60
70
Time(sec)
diff_uego11
0.4
0.2
0
Time(sec)
Calculated hash and hash threshold


one rpm window
10 sec counter, error counter
350
300
250
200
150
100
50
0
2000
4000
6000
8000
10000
12000
Time(sec)
hash error counter and threshold

| Air Fuel Ratio Imbalance Operation | |
|---|---|
| DTCs | P219A – Bank 1 Air-Fuel Ratio Imbalance |
| Monitor execution | Once per driving cycle during closed loop |
| Monitor Sequence | Monitor runs after fuel monitor has adapted |
| Sensors OK | ECT, IAT, MAF, VSS, TP, ETC, FRP, DPFE EGR, VCT, VMV/EVMV, CVS, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, rear HO2S heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no UEGO circuit malfunction, no rear stream 2 HO2S circuit malfunction, no rear stream 2 HO2S functional DTCs, no rear stream 2 HO2S response rate malfunction. |
| Monitoring Duration | Time to complete monitor ranges from 300 to 700 seconds |

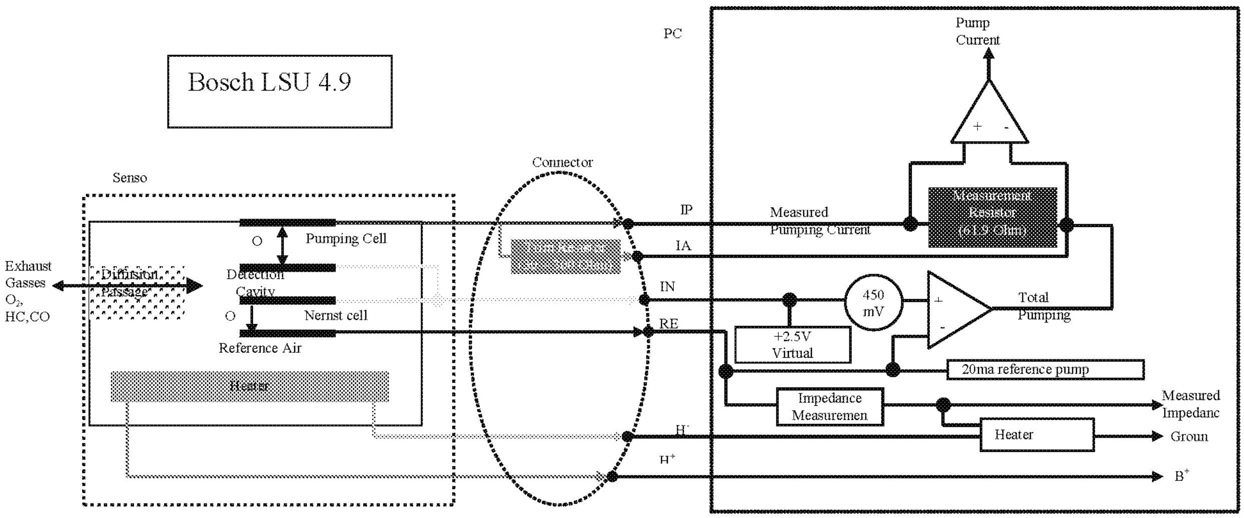
| Air Fuel Ratio Imbalance entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop Fuel Control | | |
| Engine Air Mass | 1.5 lb/min | 10 lb/min |
| Engine RPM | 1250 rpm | 2750 rpm |
| Engine Load | 5% | 75% |
| Engine Coolant Temp | 150 $^{o}$F | 235 $^{o}$F |
| Intake Air Temp | 20 $^{o}$F | 150 $^{o}$F |
| Throttle Position Rate of Change | | 0.122 v/100 msec |
| Fuel percentage from purge | | 40% |
| Fuel Level | 15% | |
| Fuel monitor has adapted | | |
| No purge on/off transition | | |
| Fuel type leaning is complete (FFV only) | | |

| Air Fuel Ratio Imbalance malfunction thresholds: |
|---|
| Imbalance Ratio Bank 1 > .65 |

| J1979 AFIMN MONITOR MODE $06 DATA | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| $81 | $80 | Bank 1 imbalance-ratio and max. limit (P219A/P219B) | unitless |

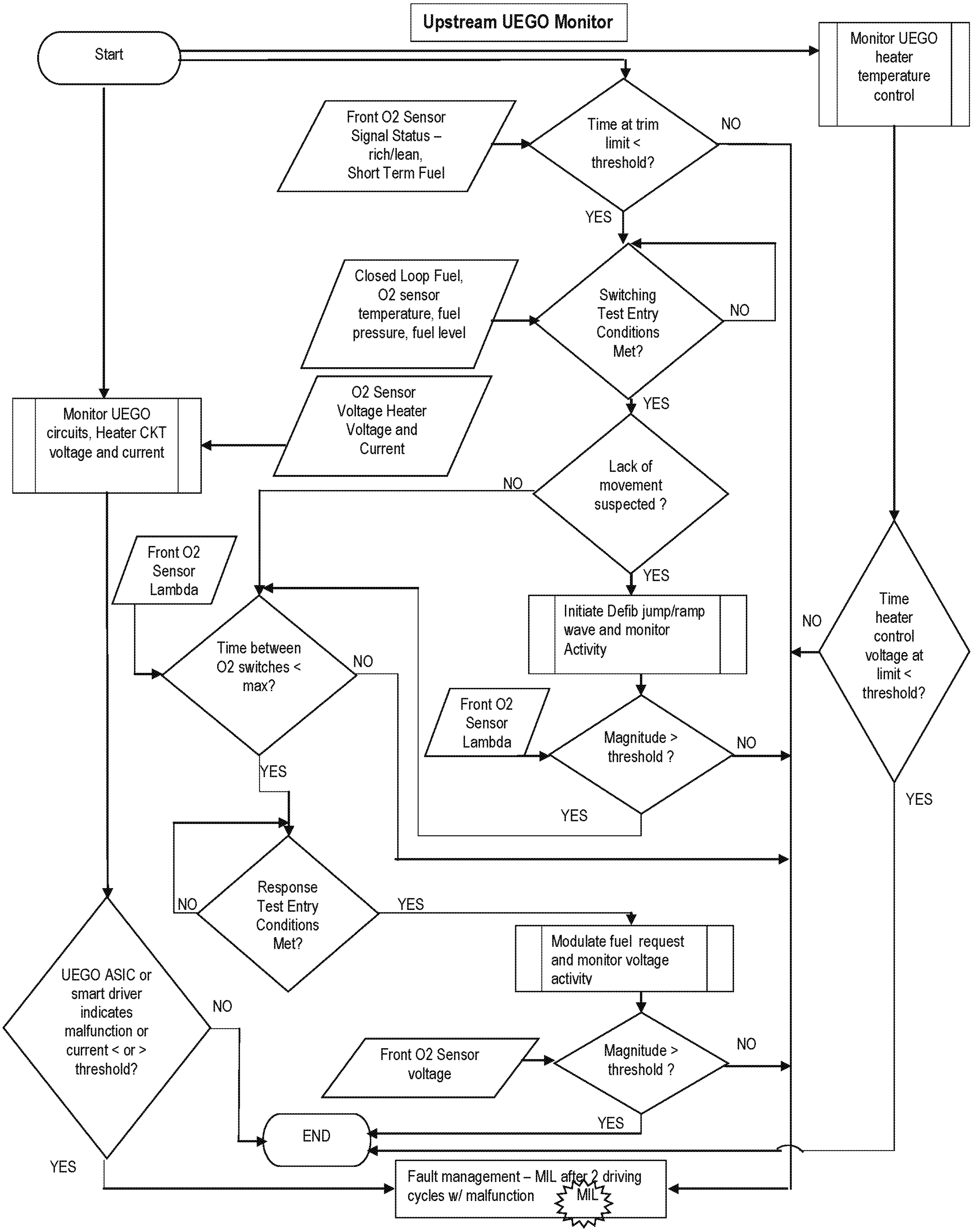
## Front UEGO Signal

The UEGO sensor infers an air fuel ratio relative to the stoichiometric (chemically balanced) air fuel ratio by balancing the amount of oxygen pumped in or out of a measurement chamber. As the exhaust gasses get richer or leaner, the amount of oxygen that must be pumped in or out to maintain a stoichiometric air fuel ratio in the measurement chamber varies in proportion to the air fuel ratio. By measuring the current required to pump the oxygen in or out, the air fuel ratio (lambda) can be estimated. Note that the measured air fuel ratio is actually the output from the UEGO ASIC pumping current controller and not a signal that comes directly from the sensor.




Bosch UEGO sensor interface:

- IP – primary pumping current that flows through the sensing resistor
- IA – current flow through trim resistor in parallel with sense resistor.
- VM – Virtual ground, approximately 2.5 volts above PCM ground.
- RE – Nernst cell voltage, 450mv from VM. Also carries current for pumped reference.
- H+ – Heater voltage – to battery.
- H- – Heater ground side – Duty cycle on/off to control sensor temperature.



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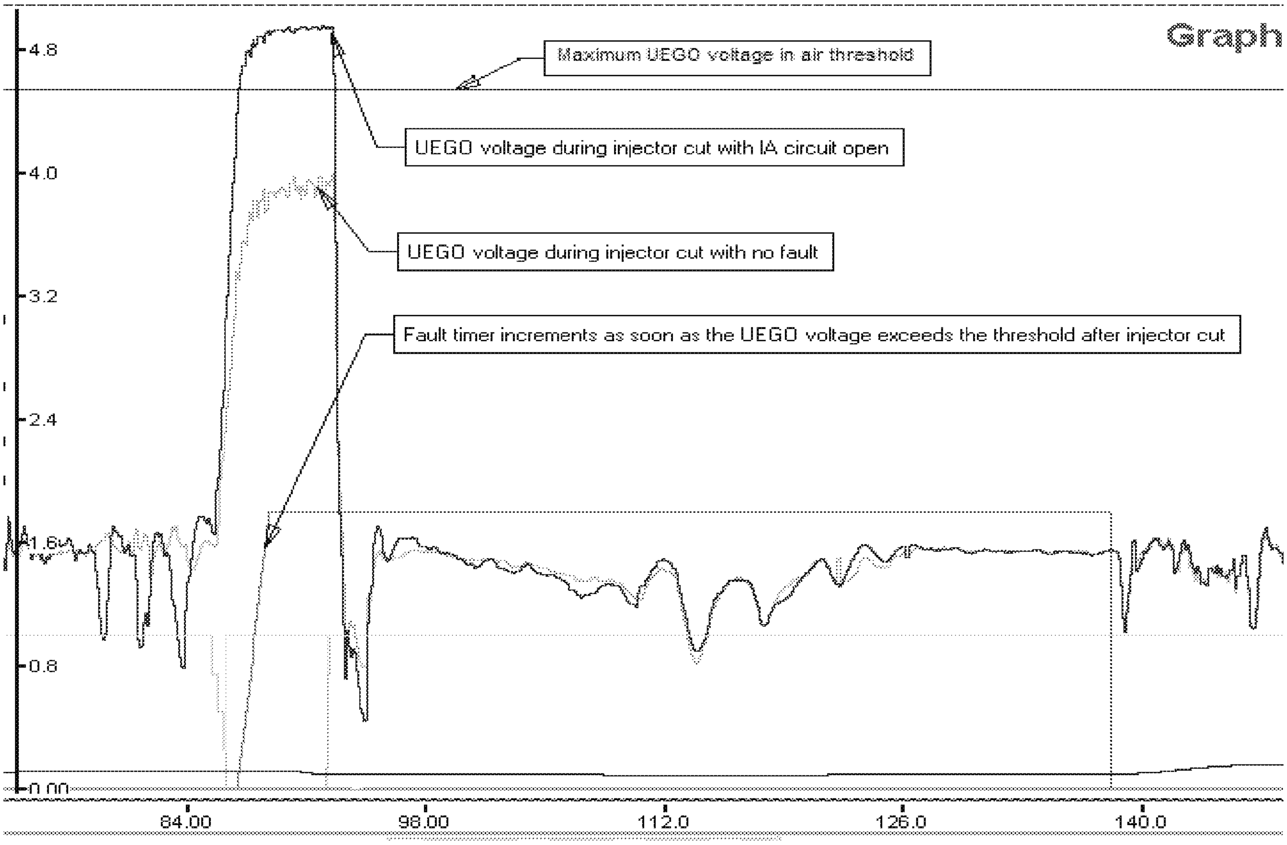
The primary component of a UEGO sensor is the diffusion passage that controls the flow of exhaust gasses into a detection cavity, a Nernst cell (essentially an EGO sensor inside the UEGO sensor) that measures the air fuel ratio in the detection cavity. A control circuitry in the ASIC chip (mounted in the PCM) controls the pumping current (IP) to keep the detection cavity near stoichiometry by holding the Nernst cell at 450 mV. This Nernst cell voltage (RE, VS) is 450mV from the virtual ground (VM, COM), which is approximately 2.5V (Bosch UEGO) or 3.6V (NTK UEGO) above the PCM ground. For the Nernst cell to generate a voltage when the detection cavity is rich, it needs an oxygen differential across the cell. In older UEGO (and HEGO) sensor designs, this was provided by a reference chamber that was connected to outside air through the wire harness that was subject to contamination and "Characteristic Shift Down (CSD)". The new UEGO sensor uses a pumped reference chamber, which is sealed from the outside to eliminate the potential for contamination. The necessary oxygen is supplied by supplying a 20 mA pumping current across the Nernst cell to pump small amounts of oxygen from the detection cavity to the reference chamber. The pumping cell pumps oxygen ions in and out of the detection cavity from and to the exhaust gasses in response to the changes in the Nernst cell voltage. The pumping current flows through the sense resistor and the voltage drop across the sense resistor is measured and amplified. Offset volts are sent out of the ASIC to one of the PCM's A/D inputs. The PCM measures the voltage supplied by the ASIC, determines the pumping current, and converts the pumping current to measured lambda. In general, the circuitry that measures the pumping current is used to estimate the air fuel ratio in the exhaust system.

The UEGO sensor also has a trim (IA) or label resistor (RL). The biggest source of part to part variability in the measured air fuel ratio is difference in the diffusion passage. This source of variation is simply the piece-to-piece differences from the manufacturing process. To compensate for this source of error, each sensor is tested at the factory and a trim or label resistor is installed in the connector. The value of this resistor is chosen to correlate with the measured difference between a particular sensor and a nominal sensor

For Bosch UEGO, the trim resistor is connected in parallel to the pumping current sense resistor and the pumping current flows through both. The trim resistor adjusts the measured pumping current back to the expected nominal value at any given air fuel ratio (correcting for the sensor to sensor variations in the diffusion passage). Small trim resistors are required for sensors that require more pumping current at any particular lambda. Conversely, for sensors with lower diffusion rates than average, less pumping current is required, so a higher than average impedance trim resistor is installed. When IA circuit is open, all of the pumping current flows through the measuring resistor which increases the measured voltage. Since the pumping current is amplified, the UEGO pumping current to lambda transfer function will reflect the error. The slope of the UEGO sensor transfer function changes, which results in the wrong output of the UEGO signal (the slope of the pumping current to lambda relationship can increase or decrease). For "stoichiometric" air/fuel control applications, an open IA circuit is not monitored since the lambda error is minimal in "stoichiometric" mode. A worst case (40 ohm resistor) open IA was tested on a 2008MY 3.5L Taurus PZEV and showed no impact on tailpipe emissions.

For "Non-Stoichiometric Closed Loop (NSCL)" air/fuel control applications, a continuous open IA diagnostics (Air Rationality Test) is required since the lambda error is more significant in this mode. The air rationality test will always monitor the UEGO sensor voltage reading during Decel Fuel Shut Off (DFSO) event. The monitor compares the UEGO sensor voltage reading in air against the expected value for pure air. If the UEGO sensor voltage during DFSO exceeds the maximum UEGO voltage in air threshold, then the fault timer increments. If the fault timer exceeds the fault time threshold, then open IA DTC P2626 and/or P2629 will set. Since transient sources of fuel in the exhaust after injector cut can contribute to the UEGO sensor voltage to read lower (rich), the air rationality monitor will not call a pass until the transient sources of fuel have been exhausted and pure air entry conditions during DFSO are met (i.e. all injectors must be off, purge must be off, no fuel must be leaking around the PCV valve, and a few transport delays must have passed to allow the last fuel transients to be exhausted leaving nothing for the sensor to see, but air).




The time spent at the limits of the short term fuel trim and the time when the measured lambda is nearly 1.0 are monitored after vehicle startup when closed loop fuel has been requested, during closed loop fuel conditions, or when open loop fuel has been requested due to UEGO sensor fault. Excessive time with short term fuel trim at its limits (up to +/- 40%), or no rich / lean activity seen since startup indicates a "lack of switch" malfunction. Also, excessive time without measured lambda deviating from 1.0, in spite of attempts to force activity (defib) in the measured lambda, indicates a "lack of movement" malfunction. Since “lack of switching” malfunctions can be caused by UEGO sensor malfunctions or by shifts in the fuel system, DTCs are stored that provide additional information for the “lack of switching” malfunction. Different DTCs indicate whether the sensor always indicates lean (P2195, P2197), or always indicates rich (P2196, P2198). "Lack of movement" malfunction, (Bosch UEGO application only), typically indicating a disconnected wire (pumping current, IP), results in P0134, P0154 DTCs.

UEGO equipped vehicles will also monitor the circuitry between the PCM and the UEGO sensor via the wire diagnostics capability included on the UEGO ASIC chip. The wire diagnostics will detect wires (IP, IA, VM/COM, RE/VS) shorted to battery, or ground, and in most cases will detect open circuits (IP, VM/COM, RE/VS). The diagnostic bits are transmitted to the PCM via SPI (serial peripheral interface). The SPI communication is validated continuously, and if a SPI communication failure is detected, fault code(s) P064D and/or P064E will be set. The ASIC is also capable of detecting internal circuitry failure; in which case, an ASIC failure DTC (P1646, P1647) along with the SPI communication failure DTC (P064D, P064E) will be set.

| UEGO “Lack of Switching” Operation: | |
|---|---|
| DTCs | P2195 - Lack of switching, sensor indicates lean, Bank 1<br>P2196 - Lack of switching, sensor indicates rich, Bank 1 |
| Monitor execution | continuous, from startup and while in closed loop fuel or open loop fuel due to UEGO sensor fault |
| Monitor Sequence | None |
| Sensors OK | ECT, IAT, MAF, VSS, TP, ETC, VCT, VMV/EVMV, CVS, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, no "lack of movement" malfunction, no UEGO circuit malfunction |
| Monitoring Duration | 30 seconds to register a malfunction |

| Typical UEGO “Lack of Switching" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop or Open Loop Requested due to UEGO sensor fault | | |
| No fuel flow entering thru PCV during cold start when flashing off fuel in oil (for O2 Sensor Stuck Rich DTCs only) | | |
| Inferred Ambient Temperature | -40 $^{o}$F | |
| Time within entry conditions | 10 seconds | |
| Fuel Tank Pressure | | 10 in $H_2O$ HEV,<br>50 in $H_2O$ PHEV |
| Fuel Level | 15% | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO “Lack of Switching” malfunction thresholds: |
|---|
| Stage 1: > 60 seconds since reaching the short term fuel trim limits while closed loop fuel or<br>Stage 2: < 1 second rich or < 1 seconds lean since startup for > 60 seconds in test conditions while open loop fuel is requested due to UEGO sensor fault. |

| UEGO "Lack of Movement – Open Pump Current Circuit" Operation (Bosch UEGO only): | |
|---|---|
| DTCs | P2237 – O2 Sensor Positive Current Control Circuit/Open (Bank 1, Sensor 1) (replaces P0134) |
| Monitor execution | continuous, from startup and while in closed loop fuel or open loop fuel due to UEGO sensor fault |
| Monitor Sequence | None |
| Sensors OK | ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, UEGO heaters OK, no "lack of switching" malfunction, no "lack of movement-open reference ground circuit" malfunction, no UEGO circuit malfunction |
| Monitoring Duration | 10 - 20 seconds to register a malfunction |

| Typical UEGO "Lack of Movement – Open Pump Current Circuit " entry conditions (Bosch UEGO only): | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop or Open Loop Requested due to UEGO sensor fault | | |
| Constant lambda near stoich (~1) | 0.99 | 1.01 |
| Time since no lambda activity seen since start up | 30 sec | |
| Time since no lambda activity during intrusive Stream 1 response monitor | 3 sec | |
| Inferred Ambient Temperature | - 40 °F | |
| Injector fuel pulsewidth | 650 usec | |
| UEGO ASIC not in recalibration mode | | |
| No air passing through during valve overlap (scavenging). | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO "Lack of Movement – Open Pump Current Circuit" malfunction thresholds (Bosch UEGO only): |
|---|
| Stage 1: > 20 seconds in test conditions without lambda movement during fuel control and reference current "defib" while in closed loop fuel and < = 0.05 change in lambda movement.<br><br>Stage 2: < 0.2 seconds without lambda movement since startup for > 30 seconds in test conditions during reference current "defib" while open loop fuel is requested due to UEGO sensor fault and < = 0.05 change in lambda movement. |

| UEGO "Lack of Movement – Open Reference Ground Circuit " Operation (Bosch UEGO only): | |
|---|---|
| DTCs | P2251 – O2 Sensor Negative Current Control Circuit/Open (Bank 1, Sensor 1) (replaces P0130) |
| Monitor execution | continuous, from startup and while in closed loop fuel or open loop fuel due to UEGO sensor fault |
| Monitor Sequence | None |
| Sensors OK | ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, UEGO heaters OK, no "lack of switching" malfunction, no "lack of movement-open pump current circuit" malfunction, no UEGO circuit malfunction |
| Monitoring Duration | 10 - 20 seconds to register a malfunction |

| Typical UEGO "Lack of Movement – Open Reference Ground Circuit " entry conditions (Bosch UEGO only): | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop or Open Loop Requested due to UEGO sensor fault | | |
| Constant lambda near stoich (~1) | 0.99 | 1.01 |
| Time since no lambda activity seen since start up | 30 sec | |
| Time since no lambda activity during intrusive Stream 1 response monitor | 3 sec | |
| Injector fuel pulsewidth | 650 usec | |
| UEGO ASIC not in recalibration mode | | |
| No air passing through during valve overlap (scavenging). | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO "Lack of Movement – Open Reference Ground Circuit" malfunction thresholds (Bosch UEGO only): |
|---|
| Stage 1: > 20 seconds in test conditions without lambda movement during fuel control and reference current "defib" while in closed loop fuel and > 0.05 change in lambda movement.<br>Stage 2: > 20 seconds in test conditions without lambda movement during reference current "defib" while open loop fuel is requested due to UEGO sensor fault and > 0.05 change in lambda movement. |

UEGO equipped vehicles monitor the circuitry between the PCM and the UEGO sensor via the wire diagnostics capability included on the UEGO ASIC chip. The wire diagnostics will detect wires (IP, IA, VM/COM, RE/VS) shorted to battery, or ground, and in most cases will detect open circuits (IP, VM/COM, RE/VS). The diagnostic bits are transmitted to the PCM via SPI (serial peripheral interface). The SPI communication is validated continuously, and if a SPI communication failure is detected, fault code(s) P064D and/or P064E will be set. The ASIC is also capable of detecting internal circuitry failure; in which case, an ASIC failure DTC (P1646, P1647) along with the SPI communication failure DTC (P064D, P064E) will be set.

| UEGO "Wire Diagnostic via ASIC" Operation: | |
|---|---|
| DTCs | P0131 – O2 circuit low voltage (Bank 1, Sensor 1). (Note: Sets for short to ground on Bosch UEGO- IP, IA, RE, VM; NTK UEGO – IP, VS, COM. Replaces P0130 in Bosch UEGO applications.)<br>P0132 – O2 circuit high voltage (Bank 1, Sensor 1). (Note: Sets for short to battery on Bosch UEGO- IP, IA, RE, VM; NTK UEGO – IP, VS, COM. Replaces P0130 in Bosch UEGO applications.)<br>P1646 – Linear O2 sensor control chip, Bank 1.<br>P064D – Internal control module O2 sensor processor performance (Bank 1). |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | UEGO heaters OK |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical UEGO "Wire Diagnostic via ASIC" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Fault reported by UEGO ASIC | | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO "Wire Diagnostic via ASIC " malfunction thresholds: |
|---|
| UEGO ASIC indicated malfunction, DTC sets after 10 seconds when circuit failure is present. |

## Front UEGO Slow/Delayed Response Monitor (2010 MY and beyond)

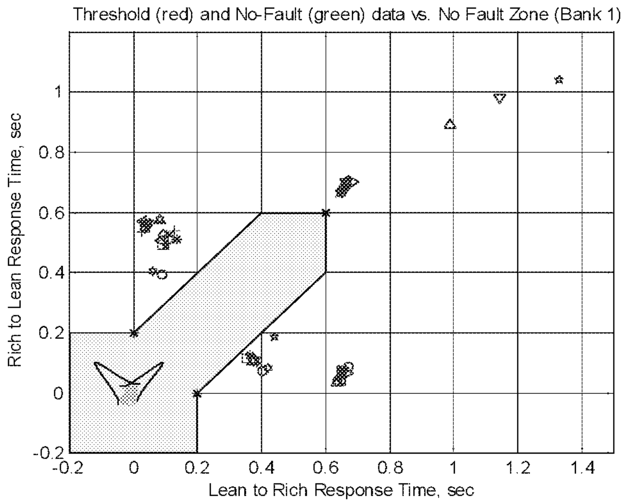
The front UEGO monitor also detects malfunctions on the UEGO sensor such as reduced response or delayed response that would cause vehicle emissions to exceed 1.5x the standard (2.5x the standard for PZEV). The response rate is evaluated by entering a special 0.5 Hz square wave, fuel control routine. This routine drives the air/fuel ratio around stoichiomentry at a calibratable frequency and magnitude, producing predictable oxygen sensor signal amplitude.

A UEGO slow or delayed sensor will show an increased response time which is compared to a no-fault polygon. Combinations of the rich to lean and lean to rich response times that fall outside the polygon indicate a sensor malfunction (P0133 Bank 1).

| UEGO "Response Rate" Operation: | |
|---|---|
| DTCs | P0133 (slow/delayed response Bank 1) |
| Monitor execution | once per driving cycle |
| Monitor Sequence | > 30 seconds time in lack of movement test, > 30 seconds time in lack of switch test |
| Sensors OK | ECT, IAT, MAF, VSS, TP, ETC, VCT, VMV/EVMV, CVS, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no UEGO circuit malfunction, no UEGO FAOS monitor malfunction |
| Monitoring Duration | 6 seconds |

| Typical UEGO "Response Rate" entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Flex Fuel Composition not changing | | |
| Not in Phase 0 of Evap Monitor, Purge intrusive test not running | | |
| No Purge System reset | | |
| Not performing CSER spark retard | | |
| Not performing intrusive UEGO Lack of Movement "defib" | | |
| No IMRC transition in progress before entering the monitor and while in monitor | | |
| Air mass stability criteria met before entering the monitor and while in monitor | | |
| Engine Coolant Temp | 130 °F | 240 °F |
| Intake Air Temp | | 140 °F |
| Time since entering closed loop fuel | 10 seconds | |
| Inferred Catalyst Midbed Temperature | | 1600 °F |
| Fuel Level | 15% | |
| Short Term Fuel Trim Range | -9% | 5% |
| Short Term Fuel Trim Absolute Change while in monitor | | 15% |
| Air Mass | 0.5 lbs/min | |
| Engine Load | 25% | 75% |
| Maximum change in engine load while in monitor | | 25% |
| Vehicle Speed | 30 mph | 80 mph |
| Maximum change in vehicle speed while in monitor | | 9 mph |
| Engine RPM | 1000 rpm | 2500 rpm |
| Maximum change in engine rpm while in monitor | | 500 rpm |
| Commanded versus actual lambda range while in monitor | 0.85 | 1.15 |
| Cam angle | | 60 |
| Cam angle movement stability criteria met while in monitor | | 2.0 |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO "Response Rate" malfunction thresholds: |
|---|
| Threshold depends on failure type (symmetric slow/delay vs. asymmetric slow/delay) |




Example shown with lean-to-rich (0.2 sec), rich-to-lean (0.2 sec), and symmetric (0.6 sec) thresholds creating the yellow no-fault zone. The completeted monitor results in two measurements, a lean-to-rich response time and a rich-to-lean response time. These response time values are used as x-y pairs to make a single point and then compared to the no-fault zone. Anywhere in the yellow is a pass and outside the yellow is a failure.

| J1979 Front UEGO Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | |
| $01 | $87 | UEGO11 Rich to Lean Response Time | seconds |
| $01 | $88 | UEGO11 Lean to Rich Response Time | seconds |

## UEGO Heaters

The UEGO heater is controlled as a function of the measured impedance to keep the sensor at a near constant temperature (Bosch: 780 deg C, NTK: 800 deg C). The impedance of the Nernst cell decreases as the sensor temperature increases. This impedance is measured by periodically applying a small current across the Nernst cell and measuring the change in the voltage. The output voltage is then sent to an A/D input on the PCM. After a cold start, the UEGO heater ramps up to the maximum duty cycle to heat the sensor. After a few seconds, the measured impedance will start to decrease and when the target value is crossed, the heater goes into closed loop heater control to maintain the sensor at a near constant temperature.

The "UEGO Heater Temperature Control Monitor" tracks the time at the maximum duty cycle during the open loop sensor warm up phase. If the measured impedance does not come down to the target value to allow the system to transition from open loop heater control to closed loop heater control within a specified time, then a fault code is set. This monitor also sets a malfunction when the closed loop heater control reaches a maximum or minimum value for a period of time indicating that the controller is no longer able to maintain the target temperature, however, if the inferred exhaust temperature is high enough that the sensor will be above the target temperature even with no heat, then this monitor is disabled.

The UEGO heaters are also monitored for proper voltage and current. A UEGO heater voltage fault is determined by turning the heater on and off and looking for corresponding voltage change in the heater output driver circuit in the PCM.

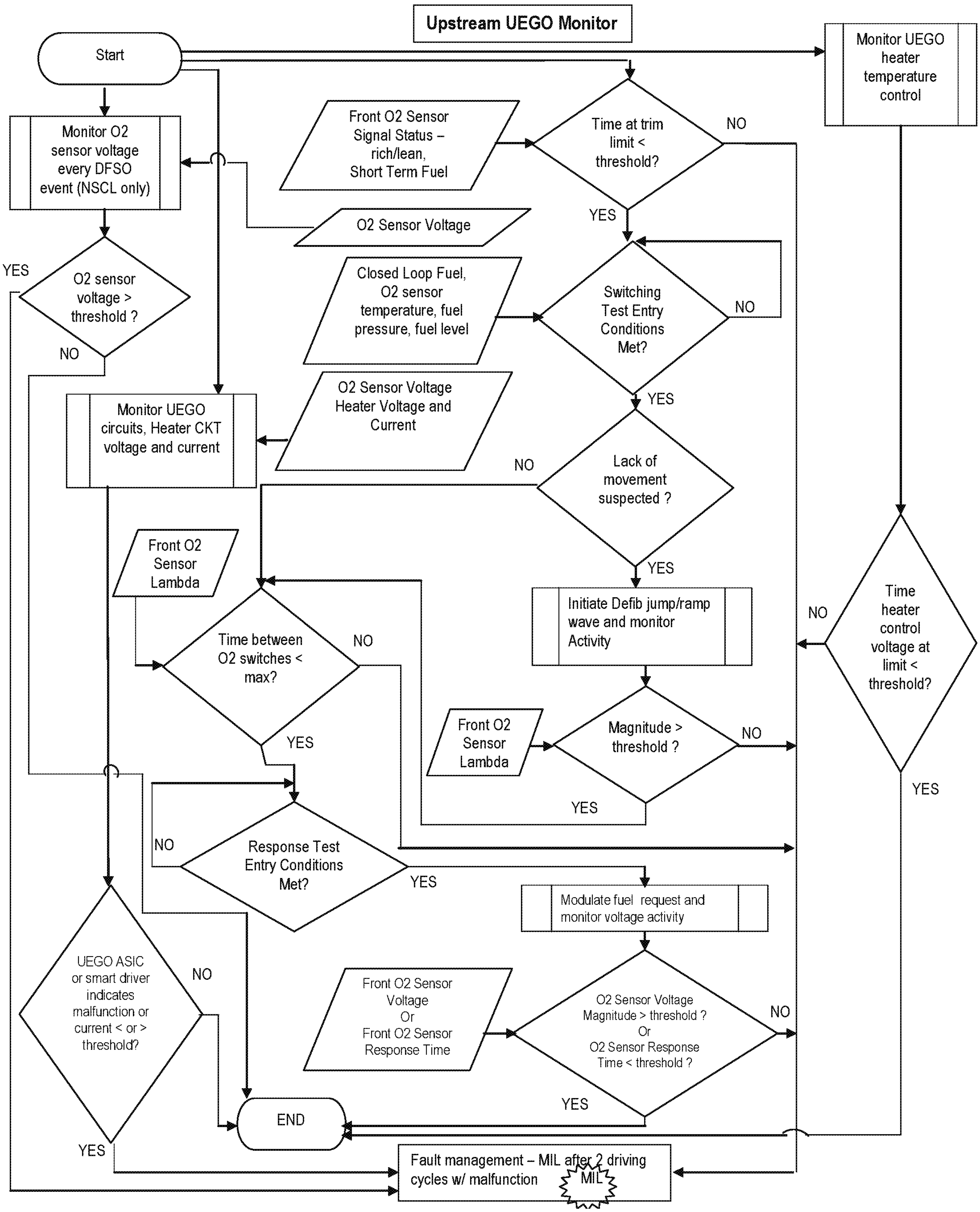
A separate current-monitoring circuit monitors heater current once per driving cycle. This monitor normally runs in closed loop heater control after all the exhaust gas sensor functional tests are completed, however, it can also run intrusively. When the UEGO sensor indicates cold, but the heater is inferred to have been adequately warm, the current monitor is forced to run intrusively prior to the completion of the heater temperature control monitor. The heater current is actually sampled three times. If the current value for two of the three samples falls below or above a calibratable threshold, the heater is assumed to be degraded or malfunctioning. (Multiple samples are taken for protection against noise on the heater current circuit.)

| UEGO Heater Monitor Operation: | |
|---|---|
| DTCs | P0030 Heater Temperature Control Failure, Bank 1<br>P0135 O2 Heater Circuit, Bank 1<br>P0053 O2 Heater Resistance, Bank 1 |
| Monitor execution | once per driving cycle for heater current monitor, continuous for voltage monitoring and heater temperature control monitoring |
| Monitor Sequence | Heater current monitor: Stream 1 UEGO response test complete, Stream 2 and 3 HO2S functional tests complete, Stream 1 UEGO heater voltage check complete.<br>Heater temperature control monitor: intrusive heater current monitor completed. |
| Sensors OK | Heater current monitor: no HO2S/UEGO heater circuit malfunction,<br>Heater temperature control monitor: no UEGO circuit malfunction, no UEGO heater circuit malfunction, no UEGO heater current monitor DTCs. |
| Monitoring Duration | < 10 seconds for heater voltage check, < 5 seconds for heater current check, >= 30 seconds for the heater temperature control monitor to register a malfunction |

| Typical UEGO heater monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Inferred UEGO unheated tip temperature (heater voltage check only) | 75 $^{o}$F | 1562 $^{o}$F |
| Inferred UEGO heated tip temperature (heater current check only) | 1346 $^{o}$F | 1526 $^{o}$F |
| UEGO heater-on time (heater current check only) | 30 seconds | |
| Engine RPM (heater current check only) | | 5000 rpm |
| Inferred UEGO unheated tip temperature (heater control monitor only) | 75 $^{o}$F | 1000 $^{o}$F |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical UEGO heater check malfunction thresholds: |
|---|
| Smart driver status indicated malfunction (heater voltage check)<br>Number monitor retries allowed for malfunction > = 30 (heater voltage check)<br>Heater current outside limits:<br>< 1.0 amps or > 3 amps (intrusive test) or < 0.55 amps or > 3 amps (Bosch UEGO)<br>Heater temperature control monitor: > = 30 seconds to register a malfunction while the heater control integrator is at its maximum or minimum limit |

| J1979 UEGO Heater Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | Units |
| $01 | $81 | HO2S11 Heater Current | Amps |
| $05 | $81 | HO2S21 Heater Current | Amps |



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# Rear HO2S Monitor

## Rear HO2S Signal

A functional test of the rear HO2S sensors is done during normal vehicle operation. The peak rich and lean voltages are continuously monitored. Voltages that exceed the calibratable rich and lean thresholds indicate a functional sensor. If the voltages have not exceeded the thresholds after a long period of vehicle operation, the air/fuel ratio may be forced rich or lean in an attempt to get the rear sensor to switch. This situation normally occurs only with a green catalyst (< 500 miles). If the sensor does not exceed the rich and lean peak thresholds, a malfunction is indicated.

2005 MY and beyond vehicles will monitor the rear HO2S signal for high voltage, in excess of 1.1 volts and store a unique DTC. (P0138, P0158). An over voltage condition is caused by a HO2S heater or battery power short to the HO2S signal line.

Some Partial Zero Emission Vehicles (PZEV Focus) may utilize three sets of HO2S sensors. The front sensors (HO2S11/HO2S21) are the primary fuel control sensors. The next sensors downstream in the exhaust are utilized to monitor the light-off catalyst (HO2S12/HO2S22). The last sensors downstream in the exhaust (HO2S13/Ho2S23) are utilized for very long term fuel trim in order to optimize catalyst efficiency (Fore Aft Oxygen Sensor Control). Ford's first PZEV vehicle uses a 4-cylinder engine so only the Bank 1 DTCs are utilized.

| Rear HO2S Functional Check Operation: | |
|---|---|
| DTCs Sensor 2 | P2270 HO2S12 Signal Stuck Lean<br>P2271 HO2S12 Signal Stuck Rich |
| Monitor execution | once per driving cycle for activity test |
| Monitor Sequence | > 30 seconds time in lack of movement test (UEGO only), > 30 seconds time in lack of switch test, front HO2S/UEGO response test complete |
| Sensors OK | ECT, IAT, MAF, VSS, TP, ETC, FRP, DPFE EGR, VCT, VMV/EVMV, CVS, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO/HO2S (front and rear) heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction (UEGO only), no UEGO/HO2S (front and rear) circuit malfunction, no UEGO FAOS monitor malfunction, no front HO2S/UEGO response rate malfunction |
| Monitoring Duration | continuous until monitor completed |

| Typical Rear HO2S functional check entry conditions: | | |
| --- | --- | --- |
| Entry condition | Minimum | Maximum |
| Stream 1 HO2S not in CSD recovery mode | | |
| Flex Fuel Composition not changing | | |
| Not in Phase 0 of Evaporative System Monitor | | |
| No Purge System reset | | |
| Purge intrusive test not running | | |
| Not performing CSER spark retard | | |
| Engine Coolant Temp | 125 $^{o}$F | 240 $^{o}$F |
| Intake Air Temp | | 140 $^{o}$F |
| Time since entering closed loop fuel | 10 seconds | |
| Inferred Catalyst Midbed Temperature | | 1600 $^{o}$F |
| Heater-on Inferred Sensor(s) 2/3 HO2S Temperature Range | 400 $^{o}$F | 1400 $^{o}$F |
| Sensor(s) 2/3 HO2S heater-on time | 90 seconds | |
| Short Term Fuel Trim Range | -5% | 5% |
| Fuel Level (forced excursion only) | 15% | |
| Inferred exhaust temperature range | 400 $^{o}$F | 1400 $^{o}$F |
| Throttle position | Part throttle | |
| Engine RPM (forced excursion only) | 1000 rpm | 2000 rpm |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical Rear HO2S functional check malfunction thresholds: |
| --- |
| Does not exceed rich and lean threshold envelope:<br>Rich < 0.42 volts<br>Lean > 0.48 volts |

| J1979 Rear HO2S Functional Check Mode $06 Data | | | |
| --- | --- | --- | --- |
| Monitor ID | Test ID | Description for CAN | |
| $02 | $01 | HO2S12 sensor switch-point voltage | volts |
| $06 | $01 | HO2S22 sensor switch-point voltage | volts |
| $03 | $01 | HO2S13 sensor switch-point voltage | volts |
| $07 | $01 | HO2S23 sensor switch-point voltage | volts |

| Rear HO2S “Over  Voltage Test” Operation: | |
|---|---|
| DTCs | P0138 HO2S12 Over voltage |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | rear HO2S heaters OK |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical HO2S “Over Voltage Test” entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Inferred Stream 2 HO2S Temperature | 400 $^{o}$F | |
| Battery Voltage | 11.0 Volts | 18.0 Volts |

| Typical HO2S “Over  Voltage Test” malfunction thresholds: |
|---|
| > 1.1 volts for 10 seconds for over voltage test |

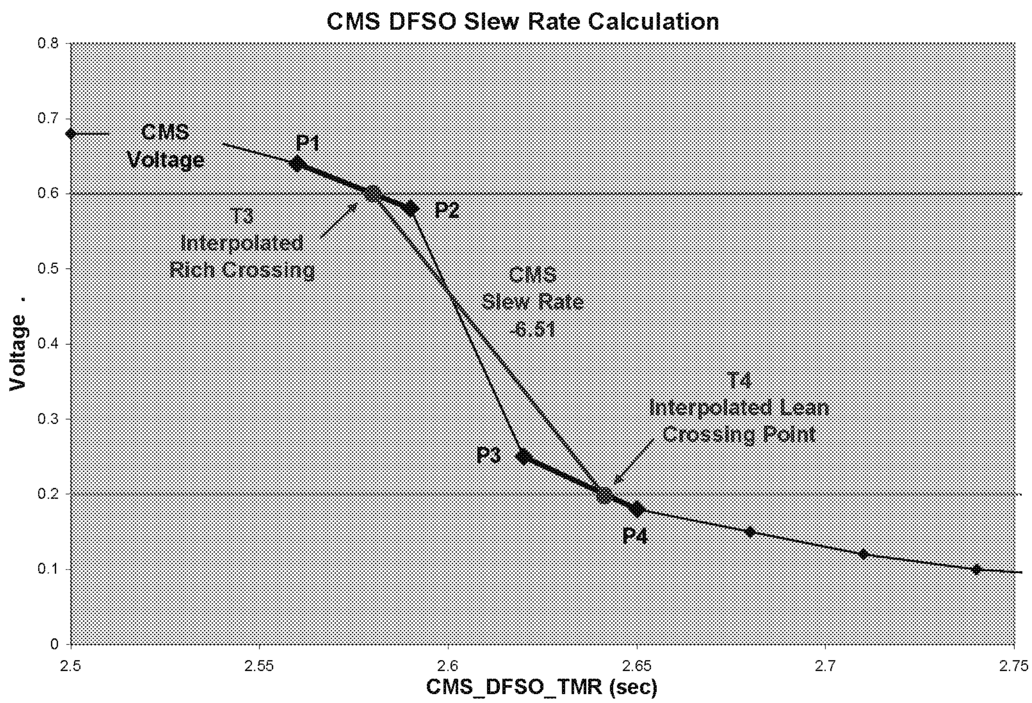
## Rear HO2S Decel Fuel Shut Off Response Test

The catalyst monitor tracks and uses the length of the rear HO2S signal. The rear HO2S is also known as the Catalyst Monitor Sensor (CMS). As the catalyst ages, air/fuel fluctuations begin to break through the catalyst and the length of this signal increases. Eventually the length of the CMS signal becomes long enough to identify a failure for the catalyst monitor.

When an HO2S sensor degrades, it's response to air/fuel fluctuations slows down. The effect of a slow rear HO2S sensor on the catalyst monitor is to reduce the length of the signal. A slow CMS sensor, therefore, may cause the catalyst monitor to incorrectly pass a failed catalyst. The purpose of the Rear DFSO Response diagnostic is to ensure the catalyst monitor has a valid CMS sensor with which to perform the catalyst monitor diagnostic. The monitor is set to trigger at the level of degradation that will cause the catalyst monitor to falsely pass a malfunction threshold catalyst.

The OBD-II regulations require this monitor to utilize Decel Fuel Shut Off (DFSO). Ford plans to aggressively use DFSO starting in the 2009 MY on many applications to improve fuel economy. The DFSO rear O2 response test will be phased in coincident with this feature.

The main part of the test is the measured rich to lean response rate. It is determined by a "slew" rate calculation which determines the rich to lean slope of the sensor during a Decel Fuel Shut Off (DFSO) event which occurs during closed pedal at vehicle speeds higher than 28 mph. The calculation for the slew rate (mV/sec) is illustrated below.



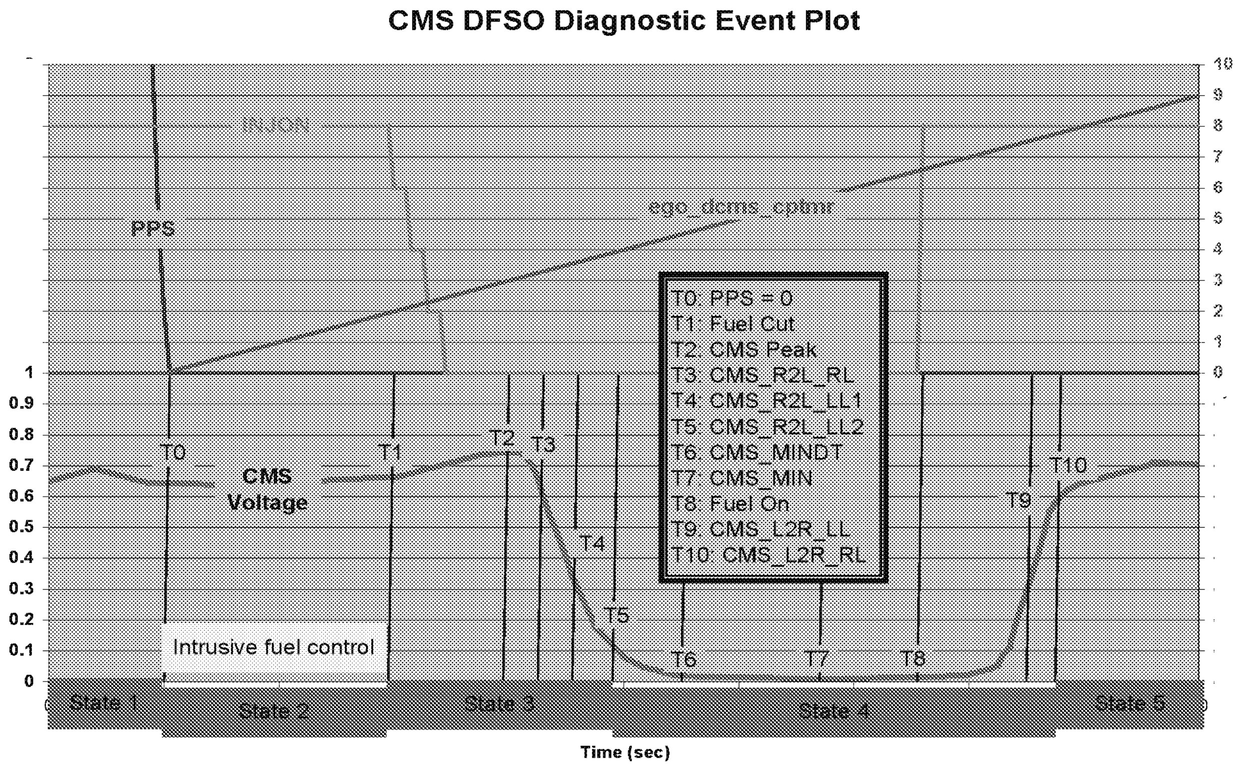

Linear interpolation is performed to calculate the Slew Rate.

1. Interpolate between points P1 and P2 to determine the time at which the rich limit threshold of 0.6 volts was crossed.

2. Interpolate between points P3 and P4 to determine the time at which the lean limit threshold of 0.2 volts was crossed.

3. Use the Interpolated times and the thresholds to calculate the slope or "slew rate" of the CMS sensor from 0.6 to 0.2 volts.

Diagnostic Data Acquisition Event Plot is a schematic of what happens when the pedal is closed and the engine enters DFSO.




The top half of the graph shows the following signals:

Closed pedal timer (ego_dcms_cptmr).

PPS (Pedal Position Sensor)

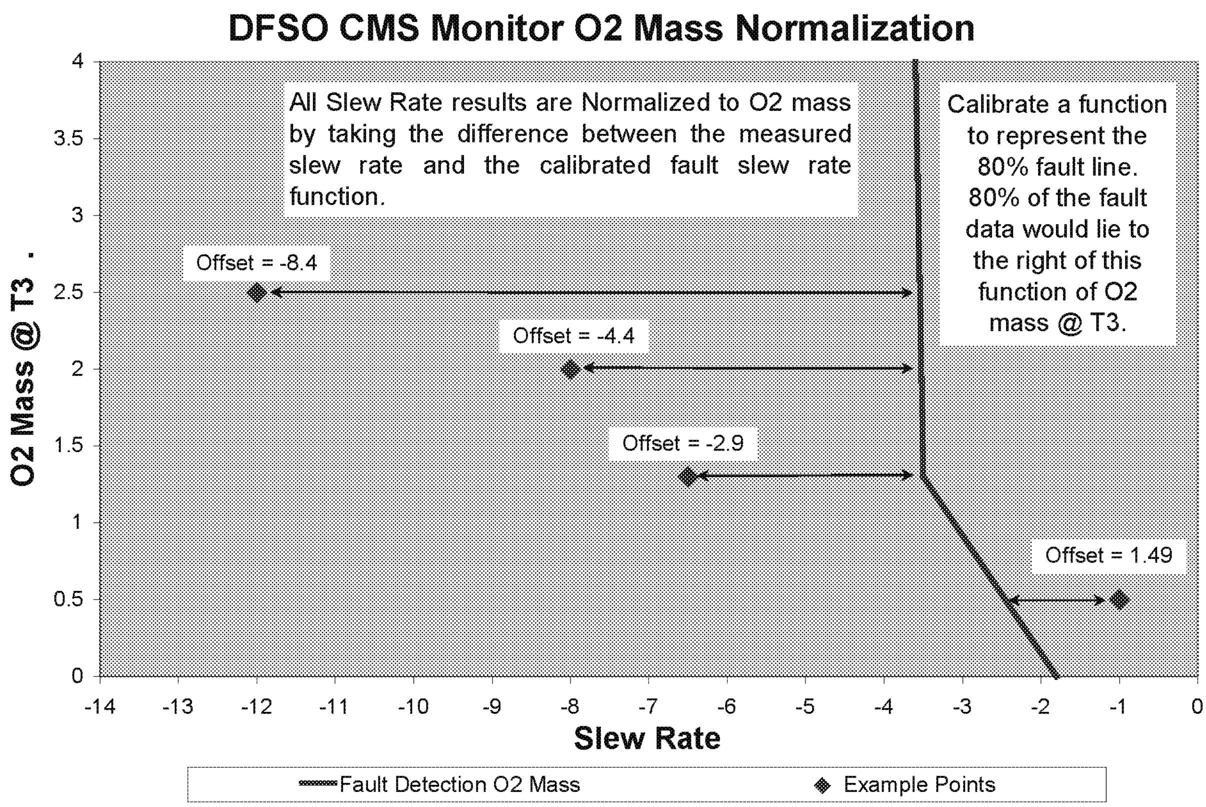
INJON (# of fuel injectors turned on)

The bottom half of the graph shows a CMS signal with black lines and a "Tx" number representing all of the points of interest where the monitor captures data.

The monitor measures the CMS Rich to Lean slew rate during a DFSO event. The CMS voltage must be rich prior to the injector cut for a valid measurement event. Each fuel cut can only yield 1 valid event. The monitor will complete after 3 valid events. Additional valid event results will be stored and applied over the next drive cycle if necessary for monitor completion.

The slope or slew rate of the CMS sensor going from rich to lean is a negative number with the units of mVolts/sec. The measured slew rate changes as an O2 sensor degrades, but it will also change as a function of catalyst oxygen storage/age; therefore, the slew rate is normalized using an offset based on catalyst oxygen storage/age. The catalyst oxygen storage/age is calculated by integrating the level of oxygen mass in the exhaust stream from the time the injectors turn off to the time where the slew rate calculation begins. The fault line (red line in the chart below) is calibrated to 80% of the fault distribution for various levels of oxygen storage/catalyst age. As shown below, the integrated oxygen mass becomes smaller with catalyst age.

The final output of the monitor = the measured slew rate – normalized fault line, therefore, any positive number will represent a fault. For the step change logic the fault threshold will represent 50% of the failed distribution (~ 0.3).



The delayed response part of the test indicates that the sensor is stuck in range. The code sets if the sensor can't get above a calibrated rich or lean voltage prior to a calibrated time out period. This time out must happen three times in a row to set the fault. If it happens once or twice and then the response monitor completes, the counter will be reset and the sensor will have to fail 3 times in a row to again set the DTC.

Due to the fact that intrusively driving the CMS sensor rich will cause drivability and emission concerns, there are other several condition counters that have to fail prior to intrusively forcing the sensor to go rich. The sequence of events to get to the rich failure is shown below:

- Initially, in order to avoid excess emissions, the monitor will only run if the CMS voltage is rich (> 0.6 volts) or CMS sensor is transitioning from lean to rich (large positive slope . 0.2).
  - Successive failures are counted up; when the count exceeds 5 to 10 failures the monitor will now intrusively force rich fuel to run the test.
- In order to avoid a drivability issues as a result of a lean shifted bank, the first phase of intrusive control has a short time out (1 to 2 seconds).
  - Successive failures are counted up; when the count exceeds 3 failures the monitor will now intrusively force rich fuel to failure or a rich sensor.
- All controllable measures have failed to force the sensor to switch, so the strategy will drive rich until the sensor switches or the failure time out is exceeded (5 to 10 seconds).
  - Successive failures are counted up; when the count exceeds 3 failures the monitor will now set a fault (P013E for bank 1 or P014A for bank 2).

If the sensor is stuck rich (can't get lean) the fault procedure is:

- While the injectors remain off, the sensor must get lean (<0.1 volts) prior to the failure time which must be set to account for a green catalyst (5 to 10 seconds).
  - Successive failures are counted up; when the count exceeds 3 failures the monitor will now set a fault (P013E for bank 1 or P014A for bank 2).

**EWMA Fault Filtering**

The EWMA logic incorporates several important CARB requirements. These are:

- Fast Initial Response (FIR): The first 4 tests after a battery disconnect or code clear will process unfiltered data to quickly indicate a fault. The FIR will use a 2-trip MIL. This will help the service technician determine that a fault has been fixed.

- Step-change Logic (SCL): The logic will detect an abrupt change from a no-fault condition to a fault condition. The SCL will be active after the 4th DCMS monitor cycle and will also use a 2-trip MIL. This will illuminate the MIL when a fault is instantaneously induced.

- Normal EWMA (NORM): This is the normal mode of operation and uses an Exponentially Weighted Moving Average (EWMA) to filter the EONV test data. It is employed after the 4th EONV test and will illuminate a MIL during the drive cycle where the EWMA value exceeds the fault threshold. (1 trip MIL).

| Rear O2 DFSO Response Monitor Operation: | |
|---|---|
| DTCs | P013A - O2 Sensor Slow Response - Rich to Lean (Bank 1 Sensor 2)<br>P013E - O2 Sensor Delayed Response - Rich to Lean (Bank 1 Sensor 2) (sensor stuck in range) |
| Monitor execution | Once per driving cycle, after 3 DFSO events. |
| Monitor Sequence | > 30 seconds time in lack of movement test (UEGO only), > 30 seconds time in lack of switch test, front HO2S/UEGO response test complete, HO2S 2 and 3 functional tests complete, HO2S/UEGO heater voltage and current checks complete, FAOS monitor system bias maturity met (UEGO applications only) |
| Sensors OK | ECT, IAT, MAF, VSS, TP, ETC, FRP, EGR, VCT, VMV/EVMV, CVS, FTP, CKP, CMP, ignition coils, injectors, no misfire DTCs, no system failures affecting fuel, no EVAP gross leak failure, UEGO heaters OK, rear HO2S heaters OK, no "lack of switching" malfunction, no "lack of movement" malfunction, no UEGO circuit malfunction, no rear stream 2 HO2S circuit malfunction, no rear stream 2 HO2S functional DTCs, Not performing CSER spark retard. Flex fuel composition not changing. No intrusive EGO monitors running. |
| Monitoring Duration | 3 DFSO events. |

| Typical DFSO Response Monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Air Mass | 0.2 | 7 |
| Vehicle Speed | | 90 |
| Inlet Air Temp | | 140 |
| Engine Coolant Temp | 130 °F | 240 °F |
| Catalyst Temperature (Inferred) | 800 °F | 1600 °F |
| Rear Ego Tip Temperature (Inferred) | 800 °F | |
| Fuel Level | 15% | |
| Fuel In Control | -9% | 5% |
| Adaptive Fuel Within Limits | -5% | 5% |
| Battery Voltage | 11.0 Volts | 18.0 Volts |
| Rich Voltage on downstream CMS sensor(s) | 0.6 Volts | |
| Rich Voltage on upstream HEGO / UEGO sensor(s) | 0.45 Volts (HEGO) | 1 (UEGO) |

| Typical DFSO response rate malfunction thresholds: |
|---|
| Rich to lean slew rate thresholds:<br>Normal Threshold = > 0.0 mV/sec<br>Fast Initial Response Threshold = > 0.0 mV/sec<br>Step Change Threshold = > 0.3 mV/sec<br>Note that the thresholds use a normalized offset and the threshold is set at "zero". |

| Typical DFSO delayed response malfunction thresholds: |
|---|
| Successive failures are counted up (5 to 10 faults). Monitor will now intrusively force rich fuel to run the test.<br>Intrusive controls will time out based on drivability (1 to 2 sec).<br>Successive drivability failures are counted up (3 faults).<br>Intrusive controls will now time out at a slower time (5 to 10 sec) and count a fault. After 3 faults are counted, a DTC is set. |

| J1979 DFSO response rate Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | |
| $02 | $85 | HO2S12 Fuel Shut off Rich to Lean Response Rate | mV/sec |
| $02 | $86 | HO2S12 Fuel Shut off Rich to Lean Response Time | msec |
| $06 | $85 | HO2S22 Fuel Shut off Rich to Lean Response Rate | mV/sec |
| $06 | $86 | HO2S22 Fuel Shut off Rich to Lean Response Time | msec |

## Rear HO2S Heaters,

The HO2S heaters are monitored for proper voltage and current. A HO2S heater voltage fault is determined by turning the heater on and off and looking for corresponding voltage change in the heater output driver circuit in the PCM.

A separate current-monitoring circuit monitors heater current once per driving cycle. The heater current is actually sampled three times. If the current value for two of the three samples falls below a calibratable threshold, the heater is assumed to be degraded or malfunctioning. (Multiple samples are taken for protection against noise on the heater current circuit.)

| HO2S Heater Monitor Operation: | |
|---|---|
| DTCs Sensor 2 | P0141 O2 Heater Circuit, Bank 1<br>P0054 O2 Heater Resistance, Bank 1 |
| Monitor execution | once per driving cycle for heater current, continuous for voltage monitoring |
| Monitor Sequence | Heater current monitor: Stream 1 HO2S/UEGO response test complete, Stream 2 and 3 HO2S functional tests complete, HO2S/UEGO heater voltage check complete |
| Sensors OK | Heater current monitor: no HO2S/UEGO heater voltage DTCs |
| Monitoring Duration | < 10 seconds for heater voltage check, < 5 seconds for heater current check |

| Typical HO2S heater monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Inferred HO2S 2/3 Temperature (heater voltage check only) | 400 $^{o}$F | 1400 $^{o}$F |
| Inferred HO2S 2 Temperature (heater current check only) | 250 $^{o}$F | 1400 $^{o}$F |
| Inferred HO2S 3 Temperature (heater current check only) | 250 $^{o}$F | 1400 $^{o}$F |
| HO2S 1/2/3 heater-on time (heater current check only) | 30 seconds | |
| Engine RPM (heater current check only) | | 5000 rpm |
| Battery Voltage (heater voltage check only) | 11.0 | 18.0 Volts |

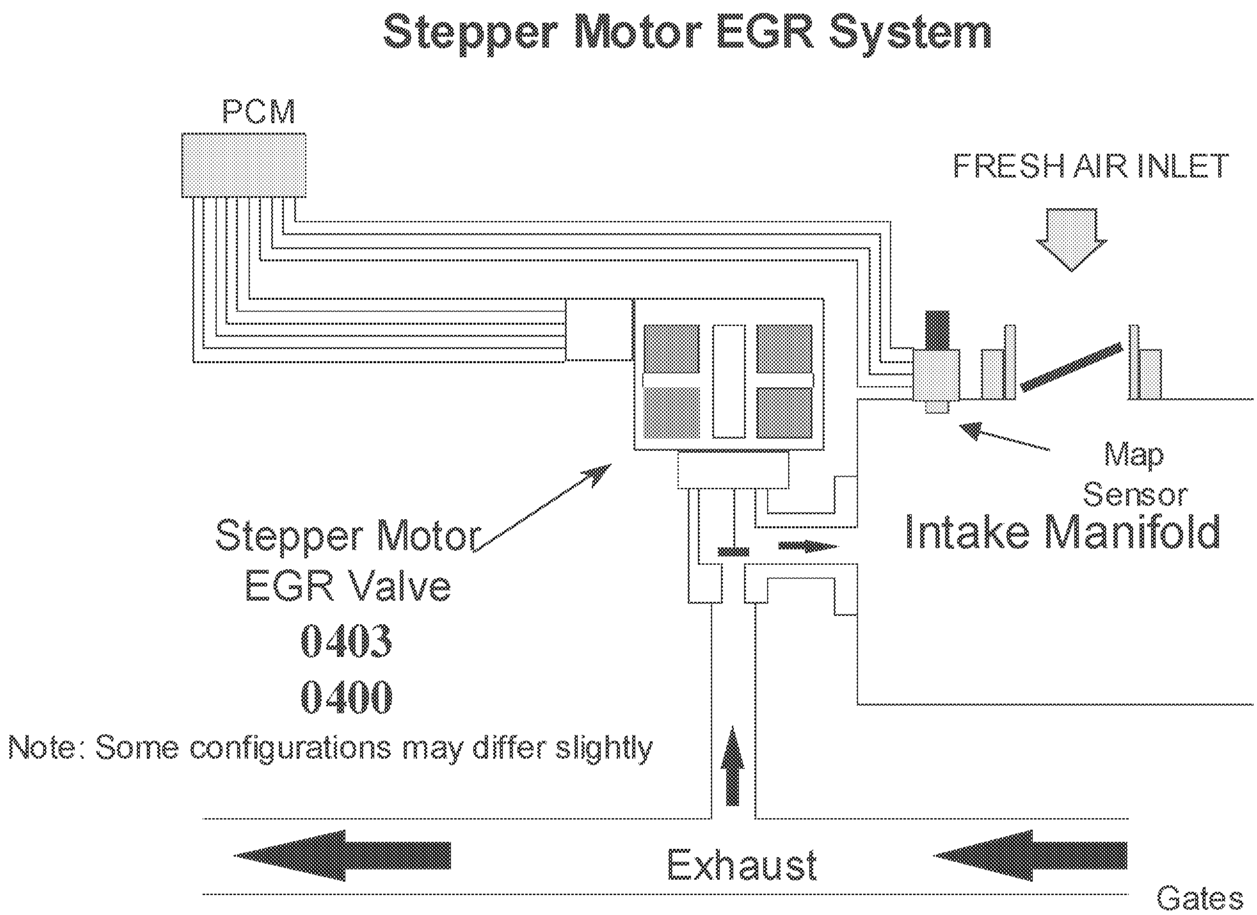
| Typical HO2S heater check malfunction thresholds: | |
|---|---|
| Smart driver status indicated malfunction | |
| Number monitor retries allowed for malfunction > = 30 | |
| Heater current outside limits: | < 0.220 amps or > 3 amps, (NTK) |
| | < 0.400 amps or > 3 amps, (Bosch) |
| | < 0.465 amps or > 3 amps, (NTK Fast Light Off) |
| | < 0.230 amps or > 3 amps, (Bosch Fast Light Off) |

**J1979 HO2S Heater Mode $06 Data**

| Monitor ID | Test ID | Description for CAN | Units |
|---|---|---|---|
| $02 | $81 | HO2S12 Heater Current | Amps |
| $06 | $81 | HO2S22 Heater Current | Amps |
| $03 | $81 | HO2S13 Heater Current | Amps |
| $07 | $81 | HO2S23 Heater Current | Amps |

## Stepper Motor EGR System Monitor

The Electric Stepper Motor EGR System uses an electric stepper motor to directly actuate an EGR valve rather than using engine vacuum and a diaphragm on the EGR valve. The EGR valve is controlled by commanding from 0 to 52 discreet increments or "steps" to get the EGR valve from a fully closed to fully open position. The position of the EGR valve determines the EGR flow. Control of the EGR valve is achieved by a non-feedback, open loop control strategy. Because there is no EGR valve position feedback, monitoring for proper EGR flow requires the addition of a MAP sensor.



The Stepper Motor EGR Monitor consists of an electrical and functional test that checks the stepper motor and the EGR system for proper flow.

The stepper motor electrical test is a continuous check of the four electric stepper motor coils and circuits to the PCM. A malfunction is indicated if an open circuit, short to power, or short to ground has occurred in one or more of the stepper motor coils for a calibrated period of time. If a malfunction has been detected, the EGR system will be disabled, and additional monitoring will be suspended for the remainder of the driving cycle, until the next engine start-up.

| EGR Stepper Monitor Electrical Check Operation: | |
|---|---|
| DTCs | P0403 |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | |
| Monitoring Duration | 4 seconds to register a malfunction |

| Stepper motor electrical check entry conditions: |
|---|
| Battery voltage > 11.0 volts |

| Typical EGR electrical check malfunction thresholds: |
|---|
| "Smart" Coil Output Driver status indicates open or short to ground, or short to power |

EGR flow is monitored using an analog Manifold Absolute Pressure Sensor (MAP). If a malfunction has been detected in the MAP sensor, the EGR monitor will not perform the EGR flow test.

The MAP sensor is checked for opens, shorts, or out-of-range values by monitoring the analog-to-digital (A/D) input voltage.

| MAP Sensor Check Operation | |
|---|---|
| DTCs | P0107 (low voltage), P0108 (high voltage) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| MAP electrical check entry conditions: |
|---|
| Battery voltage > 11.0 volts |

| Typical MAP sensor check malfunction thresholds: |
|---|
| Voltage < 0.19 volts or voltage > 4.88 volts |

The MAP sensor is also checked for rational values. The value of inferred MAP is checked against the actual value of MAP at idle and non-idle engine operating conditions.

| MAP Sensor Rationality Check Operation | |
|---|---|
| DTCs | P0106 |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical MAP Rationality check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Change in load | | 5% |
| Engine rpm | 975 rpm | 1650 rpm |
| Throttle Angle | 1.5 degrees | 83 degrees |

| Typical MAP Rationality check malfunction thresholds: |
|---|
| Difference between inferred MAP and actual MAP > 8 in Hg |

The MAP sensor is also checked for intermittent MAP faults.

| MAP Sensor Intermittent Check Operation | |
|---|---|
| DTCs | P0109 (non-MIL) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 2 seconds to register a malfunction |

| Typical MAP Intermittent check malfunction thresholds: |
|---|
| Voltage < 0.024 volts or voltage > 4.96 volts |

When EGR is delivered into the intake manifold, intake manifold vacuum is reduced and thus manifold absolute pressure (MAP) is increased. A MAP sensor and inferred MAP are used by this monitor to determine how much EGR is flowing. A MAP sensor located in the intake manifold measures the pressure when EGR is being delivered and when EGR is not being delivered. The pressure difference between EGR-on and EGR-off is calculated and averaged. If the vehicle also has a MAF sensor fitted, then the monitor also calculates and averages an inferred MAP value in the above calculation and resulting average. After a calibrated number of EGR-on and EGR-off cycles are taken, the measured and inferred MAP values are added together and compared to a minimum threshold to determine if a flow failure (P0400) in the EGR system has occurred.

| EGR Flow Check Operation: | |
|---|---|
| DTCs | P0400 |
| Monitor execution | once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | CPS, ECT, IAT, MAF, MAP (P0106/7/8), TP, BARO not available yet |
| Monitoring Duration | 200 seconds (600 data samples) |

| Typical EGR flow check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Inferred Ambient Air Temperature | 38 °F | 200 °F |
| Engine Coolant Temperature | 130 °F | 240 °F |
| Desired EGR ass | 0.1 lbm/min | |
| Engine RPM Steady (change/0.100 sec) | | 250 rpm |
| MAP Steady (change/0.100 sec) | | 0.35 in Hg |
| Engine Load Steady (change/0.100 sec) | | 10 % |
| BARO | 22.5 "Hg | |
| Intake Manifold Vacuum | 3.5 "Hg | 12.0 "Hg |
| Vehicle Speed | 25 MPH | 80 MPH |
| Engine Throttle Angle steady(absolute change) | 0.0 degrees | 4.0 degrees |
| Purge Flow Rate | | 1 lbs/min |

| Typical EGR flow check malfunction thresholds: |
|---|
| < 1.0 MAP differential |

| J1979 Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | Units |
| $33 | $82 | Normalized MAP differential (range 0 – 2) | None |

## I/M Readiness Indication

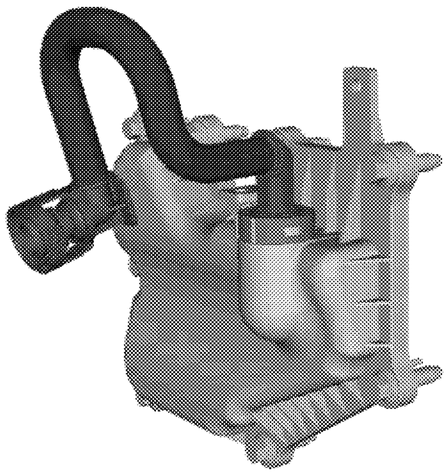
If the inferred ambient temperature is less than 20 °F, greater than 130 °F, or the altitude is greater than 8,000 feet (BARO < 22.5 "Hg), the EGR flow test cannot be reliably done. In these conditions, the EGR flow test is suspended and a timer starts to accumulate the time in these conditions. If the vehicle leaves these extreme conditions, the timer starts decrementing, and, if conditions permit, will attempt to complete the EGR flow monitor. If the timer reaches 800 seconds, the EGR flow test is disabled for the remainder of the current driving cycle and the EGR Monitor I/M Readiness bit will be set to a "ready" condition after one such driving cycle. Two such consecutive driving cycles are required for the EGR Monitor I/M Readiness bit to be set to a "ready" condition.

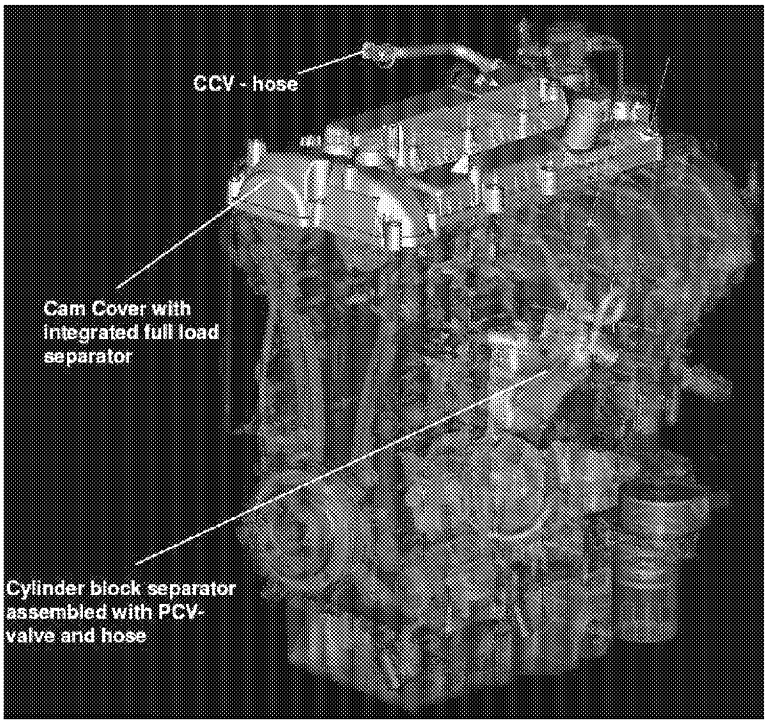
[redacted]

## PCV System Monitor

The PCV valve is installed into an oil separator that is bolted to the side of the block. The PCV valve is designed to last the full useful life of the engine and is not designed to be removed from the oil separator. The PVC valve is connected to the intake manifold hose using a quick connect. Because the PCV valve cannot be removed from the oil separator, the quick connect will be disconnected in the event vehicle service is required. Molded plastic lines are used from the PCV valve to the intake manifold. The diameter of the lines and the intake manifold have been increased to 0.625" so that inadvertent disconnection of the quick connect will cause either an immediate engine stall or will not allow the engine to be restarted. The crank case ventilation hose on the cam cover is connected to the air induction system using quick connects. The cam cover also incorporates an oil separator.

In the event that the vehicle does not stall if the line between the intake manifold and PCV valve is disconnected, the vehicle will have a large vacuum leak that will cause the vehicle to run lean at idle. This will illuminate the MIL after two consecutive driving cycles and will store one or more of the following codes: Lack of O2 sensor switches, Bank 1 (P2195), Fuel System Lean, Bank 1 (P0171).



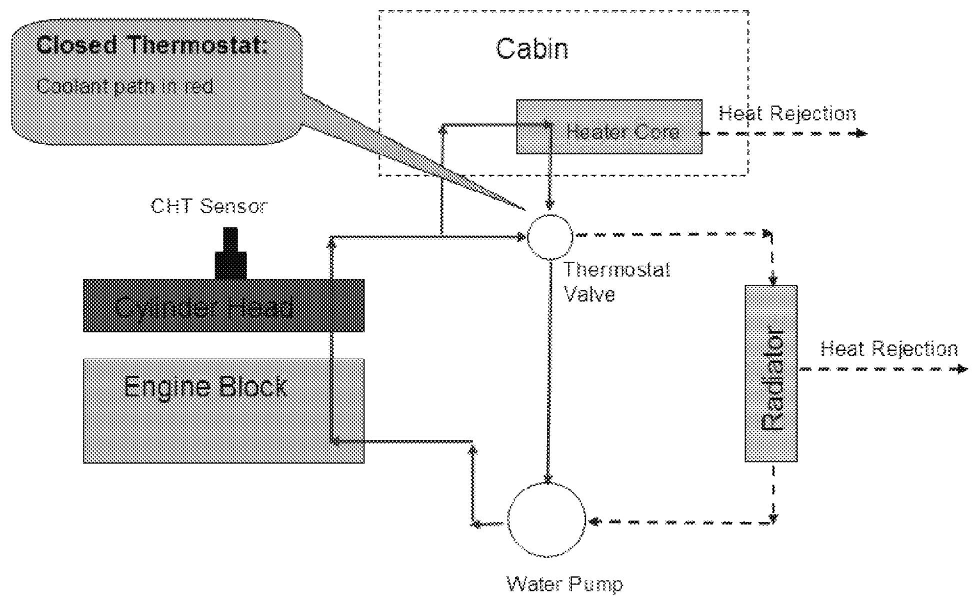


## Enhanced Thermostat Monitor

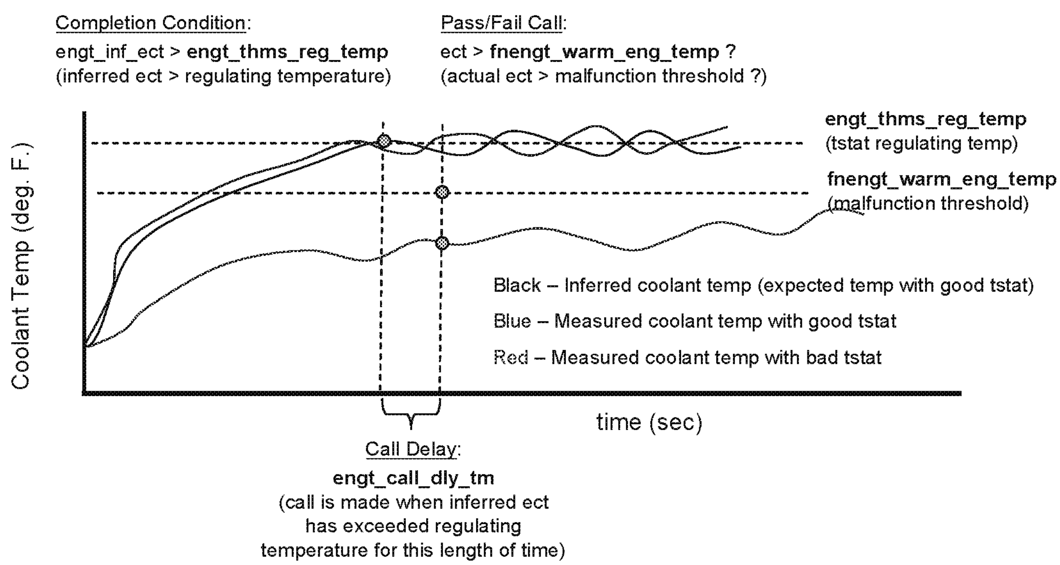
For the 2009 MY, the thermostat test has been enhanced to reduce the time it takes to identify a malfunctioning thermostat. The enhanced monitor includes a model which infers engine coolant temperature.

During a cold start, when the thermostat should be closed, the monitor uses a model of ECT to determine whether actual ECT should have crossed the Warm Up Temperature (WUT) threshold.

Engine Cooling System




Once the ECT model exceeds the thermostat regulating temperature for 3 seconds, measured ECT is compared to the WUT threshold to determine if ECT has warmed up enough. If ECT has warmed up to at least the WUT threshold, the thermostat is functioning properly. If ECT is too low, the thermostat is most likely stuck open and a P0128 is set.




The WUT threshold is normally set to 20 degrees F below the thermostat regulating temperature.

There are some circumstances that could lead to a false diagnosis of the thermostat. These are conditions where the vehicle cabin heater is extracting more heat than the engine is making. One example where this can occur is on large passenger vans which have "dual" heaters, one heater core for the driver and front passengers and another heater core for the passengers in the rear of the vehicle. At very cold ambient temperatures, even a properly functioning thermostat may never warm up to regulating temperature. Another example is a vehicle that is started and simply sits at idle with the heater on high and the defroster fan on high.

There are two features that are used to prevent a false thermostat diagnosis. For vehicles with dual heaters, the WUT threshold is reduced at cold ambient temperatures below 50 deg F. For cases where the engine is not producing sufficient heat, a timer is used to track time at idle or low load conditions (e.g. decels). If the ratio of time at idle/low load versus total engine run time exceeds 50% at the time the fault determination is made, the thermostat diagnostic does not make a fault determination for that driving cycle, i.e. "no-call".

| THERMOSTAT MONITOR OPERATION | |
|---|---|
| DTC | P0128 - Coolant Thermostat (Coolant temperature below thermostat regulating temperature) |
| Monitor Execution | Once per driving cycle, during a cold start |
| Monitoring Duration | Drive cycle dependent. Monitor completes in less than 300 seconds when inferred ECT exceeds threshold(at 70 deg F ambient temperature) |

| TYPICAL THERMOSTAT MONITOR ENTRY AND COMPLETION CONDITIONS | | |
|---|---|---|
| Entry conditions | Minimum | Maximum |
| Engine Coolant Temperature at start | None | 125 °F |
| Intake Air Temperature at start (ambient temp) | 20 °F | None |
| Inferred Percent Ethanol (flex fuel vehicles only) | Learned | N/A |
| Completion condition | Minimum | Maximum |
| Modeled ECT | 180 °F | None |
| Time Since Modeled ECT Exceeded WUT Threshold | 3 sec. | None |
| Time at Idle/Low Load Compared with Total Engine Run Time | None | 50% |

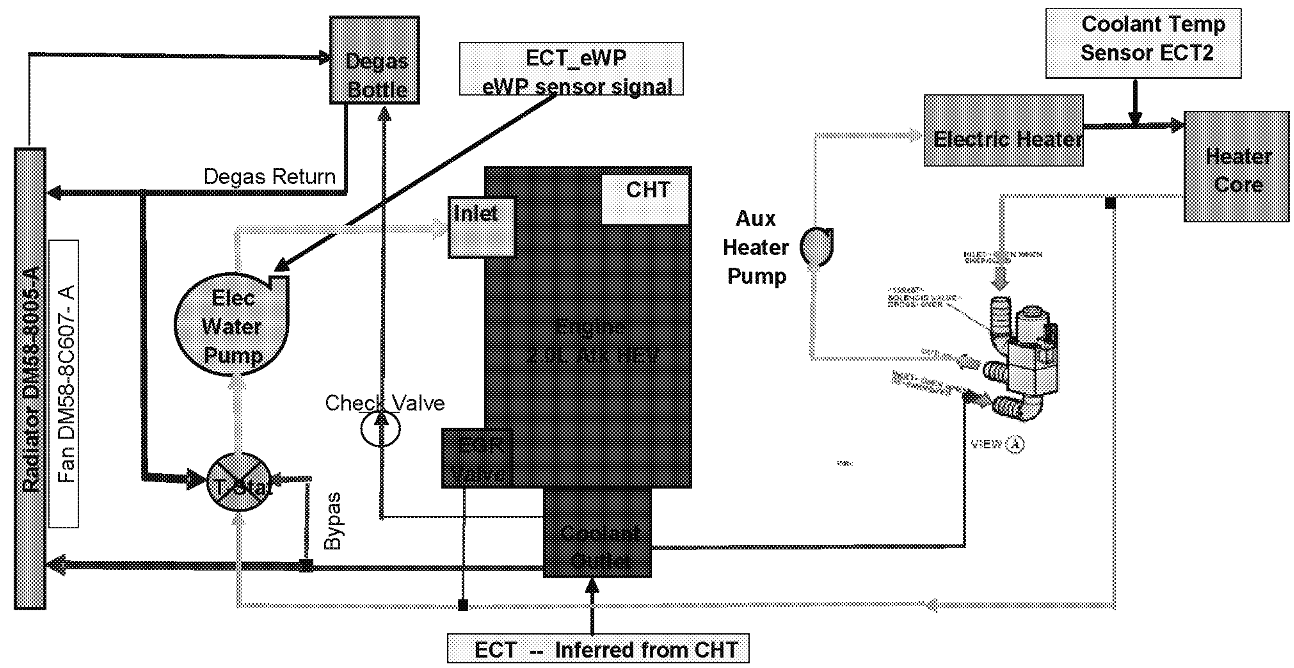
| TYPICAL MALFUNCTION THRESHOLD |
|---|
| Engine Coolant Temperature < 160 °F (for the 180 °F thermostat) |

## HEV/PHEV Cooling System Diagnostics

The cooling system in the Plug-in Hybrid has been designed to include two functional cooling loops. This system is designed to maximize cooling efficiency when the vehicle is running on either the gas engine or the electric motor. The system operates in one of two different modes.

The first mode is the main or "combined" cooling loop mode which provides coolant flow through both the gas engine and the cabin heater core. While in this loop, both the gas engine and an electric heater can be used to maximize the heat transfer to the coolant thus providing both an increase in the engine metal temperature and heat for the vehicle cabin.

The second cooling mode is the "isolated" loop mode where coolant flow through the cabin heater core is isolated from the engine block. This loop is intended to provide cabin heat when the gas engine is not running. Coolant flow is maintained in the "combined" loop by default (isolation valve de-energized), and by energizing the isolation valve coolant flow is maintained in the "isolated" loop.




While in the "combined" cooling loop, coolant flow is maintained by a PCM-controlled Engine Coolant Pump (internally known as the electric Water Pump (eWP)). The Engine Coolant Pump is a pulse width modulated pump that can be used to control coolant flow rates independent of engine speed. This allows the PCM to maximize fuel economy by minimizing cooling system power consumption as compared to a traditional belt-driven water pump. Additionally, it can be used to improve engine metal temperature heating/cooling rates. Even though the Engine Coolant Pump can provide coolant flow while the engine is off, it's primary purpose is to provide coolant flow while the engine is running. A low power consumption auxiliary water pump in the "isolation" loop is the primary source of coolant flow for cabin heating when the vehicle is operating in electric mode.

The Engine Coolant Pump (eWP) is a smart pump with four pins. Two of the pins are connected directly to battery power and electrical ground. The other circuits are connected to the PCM. One is connected to the LIN bus (primary PCM control) and the other is called the Emergency Run Input (ERI) line that can be used to control the pump with a PWM signal if the LIN bus goes down. This ERI line has been wired directly to ignition power so that the pump will be commanded to run any time the LIN bus is failed and ignition is on.

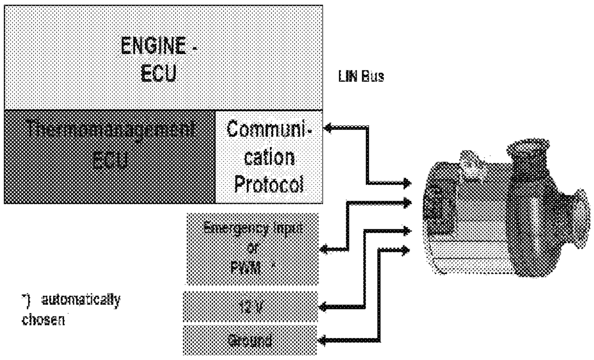



Figure 1: Electric water pump/motor assembly block diagram

Below is a summary of the diagnostics associated with the Engine Coolant Pump. Circuit faults for the LIN bus and ERI lines are detected by the PCM while the pump power and ground line faults are detected by the Engine Coolant Pump Control Module and communicated to the PCM through the LIN bus line. All mechanical faults are detected by the Engine Coolant Pump Control Module and also communicated to the PCM over the LIN bus.

The Engine Coolant Pump speed is controlled by the PCM and communicated to the Engine Coolant Pump Control Module over the LIN bus. A LIN bus communication fault (U019F) is set when the engine coolant pump speed echoed back from the Engine Coolant Pump Control Module doesn't match the desired speed sent from the PCM (requires no other electric water pump faults exist).

| Engine Coolant Pump communication check operation | |
|---|---|
| DTCs | U019F - Lost Communication With Engine Coolant Pump Control Module |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Over-temperature (P26D2), over-current (P26CB), blocked impeller (P26CB), or dry run (P26CE). |
| Monitoring Duration | 10 seconds to register a malfunction |

| Typical Engine Coolant Pump communication check malfunction thresholds: |
|---|
| Difference between desired pump speed and actual pump speed > 300 RPM |

Failures on the Emergency Run Input (ERI) line are detected by checking the status of the ERI line communicated to the PCM over LIN. Since the ERI line is hardwired to the vehicle ignition key, the returned ERI line state should always match the vehicle ignition state. When there is a mismatch, a DTC P26CA is set. This monitor requires that the LIN communications bus has not failed.

| Engine Coolant Pump Emergency Run Input check operation | |
|---|---|
| DTCs | P26CA – Engine Coolant Pump Control Circuit/Open |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Conditions | No LIN bus communication faults (U019F). |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Engine Coolant Pump Emergency Run Input check malfunction thresholds: |
|---|
| Difference between ERI state reported by ECPCM and actual ERI state at PCM |

The Engine Coolant Pump power and ground line status is not communicated to the PCM by Engine Coolant Pump Control Module. Therefore, the status of these lines is inferred by the PCM. If either of these lines is faulted, the Engine Coolant Pump will not run, and there will no LIN bus communications from the Engine Coolant Pump Control Module to the PCM. The PCM first checks to see if a fault on the communication line (U019F). If the communication line is faulted and the engine coolant temperature is increasing then it is assumed that the pump is not running and a P26D3 DTC is set. If the engine coolant temperature is not increasing then the PCM identifies the communications fault only.

| Engine Coolant Pump Control Module Power/Ground check operation | |
|---|---|
| DTCs | P26D3 – Engine Coolant Pump Supply Voltage Circuit |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Conditions | None |
| Monitoring Duration | 5 seconds to register a malfunction |

| Electric Water Pump Control Module Power/Ground Signal Fault malfunction thresholds: |
|---|
| LIN bus comm. fault (U019F) and accumulated engine coolant temp increase > $10^{o}$C |

The Engine Coolant Pump Control Module can use the rpm feedback and current feedback to detect mechanical faults for a blocked impeller and a "dry run" condition, i.e. loss of coolant. These conditions are communicated back to the PCM over the LIN bus.

| Engine Coolant Pump Mechanical Faults check operation | |
|---|---|
| DTCs | P26CB – Engine Coolant Pump Performance/Stuck Off<br>P26CE – Engine Coolant Pump Overspeed |
| Monitor execution | Continuous Operation |
| Monitor Sequence | None |
| Monitoring Conditions | No LIN bus communication faults (U019F). |
| Monitoring Duration | 5 seconds to register a malfunction |

| Engine Coolant Pump Mechanical Faults check operation malfunction thresholds: |
|---|
| P26CB: pump current too high, rpm too low for 4 restart events<br>P26CE: pump speed > 4909 rpm and current too low |

The Engine Coolant Pump Control Module communicates the control module electronics voltage and temperature over the LIN bus to the PCM. The voltage is compared to the PCM system voltage to set DTCs P26D0 and P26D1. The temperature signal is checked for out-of-range high which sets a P26D2 DTC.

| Engine Coolant Pump Control Module Electrical Faults check operation | |
|---|---|
| DTCs | P26D0 – Engine Coolant Pump Control Module System Voltage Low<br>P26D1 – Engine Coolant Pump Control Module System Voltage High<br>P26D2 - Engine Coolant Pump Control Module Over Temperature |
| Monitor execution | Continuous Operation |
| Monitor Sequence | None |
| Monitoring Conditions | No LIN bus communication faults (U019F). |
| Monitoring Duration | 5 seconds to register a malfunction |

| E Engine Coolant Pump Control Module Electrical Faults malfunction thresholds: |
|---|
| P26D0 – ECPCM voltage < (PCM battery voltage plus 4 volts)<br>P26D1 – ECPCM voltage > (PCM battery voltage plus 4 volts)<br>P26D2 – ECPCM temperature > 130°C |

## Engine Speed and Spark Timing Component Monitor (2010 MY and beyond)

### Entry Conditions and Monitor Flow

The System Monitor and 2010 Component Monitor share the same entry conditions and monitor flow. During the first 15 seconds of a cold start, the monitor checks the entry conditions, counts time in idle, observes catalyst temperature, calculates the average difference between desired and actual engine speed, and calculates the average difference between desired and commanded spark.

If the expected change in catalyst temperature is large enough, the monitor then begins the waiting period, which lasts until 300 seconds after engine start. This 5-minute wait allows time to diagnose other components and systems that affect the validity of the test. During this waiting period, there are no constraints on drive cycle and the monitor cannot be disabled without turning off the key.

If the System monitor result falls below its threshold and all of the Component monitor results are below their respective thresholds, the monitor determines whether the idle time was sufficient. If so, it considers the tests a pass and the monitor is complete. If idle time was not sufficient, the monitor does not make a pass call and does not complete. This prevents tip-ins from resulting in false passes.

### Cold Start Engine Speed Monitor

Once the waiting period is complete, the monitor compares the average difference between desired and actual engine speeds to a calibratable threshold that is a function of ECT at start. If the magnitude of the discrepancy exceeds the threshold, P050A is set.

### Cold Start Spark Timing Monitor

Once the waiting period is complete, the monitor compares the average difference between desired and commanded spark to a calibratable threshold that is a function of ECT at start. If the magnitude of the discrepancy exceeds the threshold, P050B is set.

| CSER COMPONENT MONITOR OPERATION | |
|---|---|
| Component Monitor DTCs | P050A: Cold Start Idle Air Control System Performance<br>P050B: Cold Start Ignition Timing Performance |
| Monitor Execution | Once per driving cycle, during a cold start |
| Monitor Sequence | Monitor data collection takes place during first 15 seconds of cold start |
| Sensors OK | No fault is present in any of the sensors or systems affecting the catalyst temperature model: Mass Air Flow (P0102, P0103), Throttle Position (P0122, P0123, P0222, P0223), Misfire (P0316, P0300-P0312), Injectors (P0201-P0212), Fuel System (P0171, P0172, P0174, P0175), Secondary Air (P0412, P2258), Crank Position Sensor (P0320), Ignition Coil (P0351-P0360), Intake Air Temp (P0112, P0113), Engine Coolant Temp/Cylinder Head Temp (P0117, P0118, P1289, P1290), Variable Cam Timing (P0010, P0020, P0011, P0012, P0021, P0022), Intake Manifold Runner Control (P2008). |
| Monitoring Duration | Monitor completes 300 seconds after initial engine start |

| TYPICAL CSER COMPONENT MONITOR ENTRY AND COMPLETION CONDITIONS | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Barometric Pressure | 22 in. Hg | |
| Engine Coolant Temperature at Start | 35 °F | 100 °F |
| Catalyst Temperature at Start | 35 °F | 125 °F |
| Fuel Level | 15% | |
| BARO | 22.5" Hg | |
| No Torque Reduction by Injector Cutout | | |
| Power Takeout Not Active | | |
| Completion condition | Minimum | Maximum |
| Length of Time Entry Conditions are Satisfied | 11 sec. | |
| Expected Change in Catalyst Temperature | 50 °F | |
| Time in Idle | 10 sec. | |
| Selected Gear | Neutral | Drive |

| TYPICAL CSER COMPONENT MONITOR MALFUNCTION THRESHOLDS |
|---|
| Engine speed discrepancy > 200 rpm |
| Spark timing discrepancy > 10 deg. |

## Cold Start Variable Cam Timing Monitor (2008 MY and beyond)

If the VCT cam phasing is used during a cold start to improved catalyst heating, the VCT system is checked functionally by monitoring the closed loop cam position error correction. If the proper cam position cannot be maintained and the system has an advance or retard error greater than the malfunction threshold, a cold start emission reduction (CSER) VCT control malfunction is indicated (P052A/P052B (Bank 1), P052C/P052D (Bank2). This test is the same test that was used previously for monitoring the VCT system under Comprehensive Component Monitoring requirements.

| CSER VCT Target Error Check Operation:] | |
|---|---|
| DTCs | P052A – Cold start camshaft position timing over-advanced (Bank 1)<br><br>P052B – Cold start camshaft timing over-retarded (Bank 1) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 2 seconds |

| Typical CSER VCT target error entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| VCT control enabled and commanded to advance or retard cam during CSER | n/a | n/a |
| Time since start of CSER cam phase monitoring | | 60 seconds |

| Typical CSER VCT target error malfunction thresholds: |
|---|
| CSER Response/target error - VCT over-advance: 11 degrees<br><br>CSER Response/target error - VCT over-retard: 11 degrees<br><br>CSER Response/Stuck Pin – 10 degrees phasing commanded, and not seeing at least 2 degrees of movement. |

## Cold Start Emission Reduction System Monitor

The Cold Start Emission Reduction System Monitor is being introduced for the 2007 MY on vehicles that meet the LEV-II emission standards. The System Monitor detects the lack of catalyst warm up resulting from a failure to apply sufficient CSER during a cold start. It does this by using the inferred catalyst temperature model to determine how closely the actual catalyst temperature follows the expected catalyst temperature during a cold start. How closely the actual temperature follows the expected temperature is reflected in a ratio which is compared with a calibratable threshold.

### Temperatures Used

The actual catalyst temperature is the same inferred catalyst temperature that is used by other portions of the engine control system, including the CSER control system. The inputs to this actual temperature are measured engine speed, measured air mass, and commanded spark.

The expected catalyst temperature is calculated using the same algorithm as the actual catalyst temperature, but the inputs are different. Desired engine speed replaces measured engine speed, desired air mass replaces measured air mass, and desired cold start spark replaces commanded spark. The resulting temperature represents the catalyst temperature that is expected if CSER is functioning properly.

### Ratio Calculation

A ratio is calculated to reflect how closely the actual temperature has followed the expected temperature. This ratio is the difference between the two temperatures at a certain time-since-start divided by the increase in expected temperature over the same time period. The ratio, then, provides a measure of how much loss of catalyst heating occurred over that time period.

This ratio correlates to tailpipe emissions. Therefore applying a threshold to it allows illumination of the MIL at the appropriate emissions level. The threshold is a function of ECT at engine start.

### General CSER Monitor Operation

During the first 15 seconds of a cold start, the monitor checks the entry conditions, counts time in idle, and observes catalyst temperature.

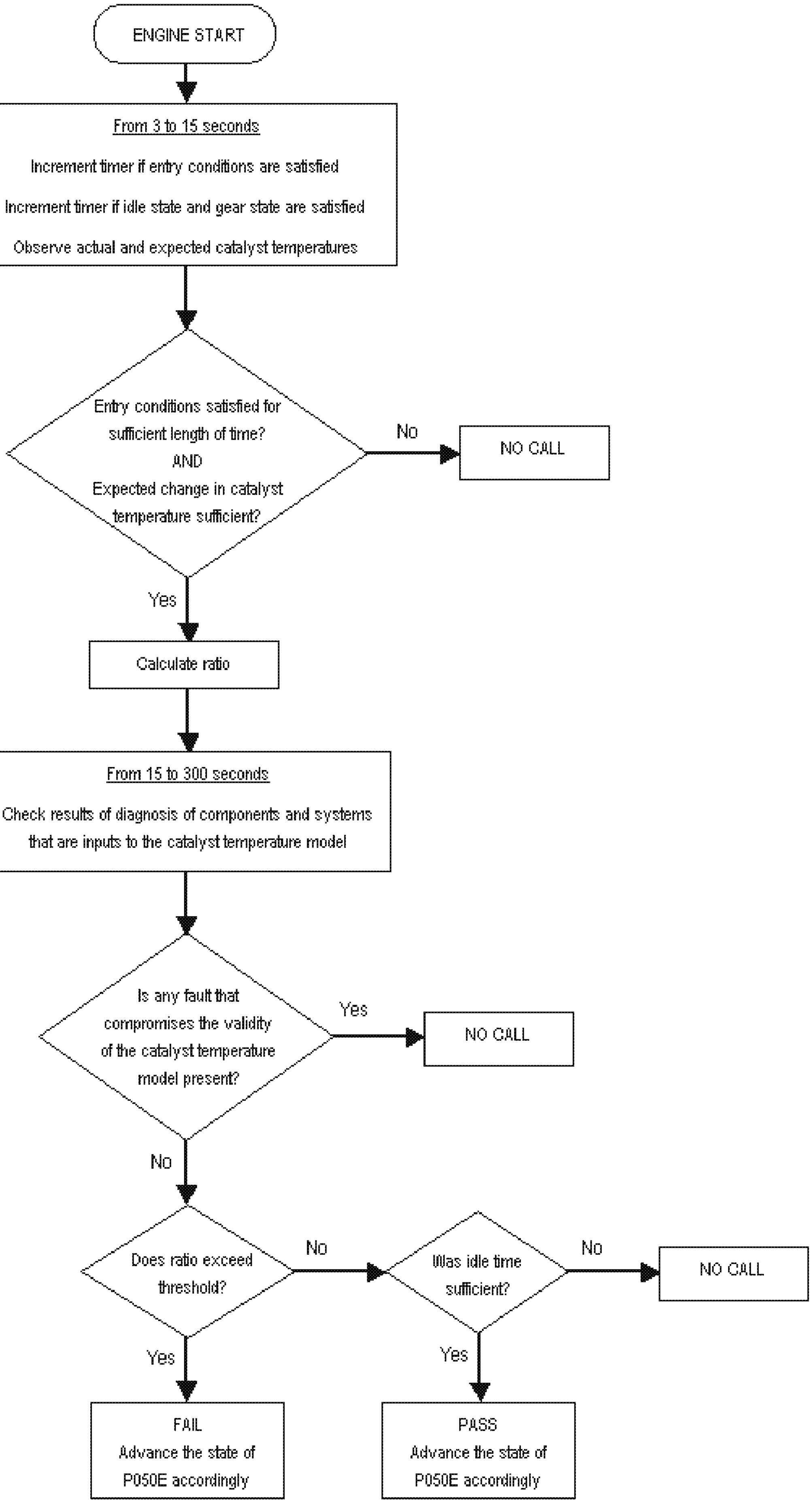
If the expected change in catalyst temperature is large enough, the monitor calculates the ratio as described above. Otherwise the monitor does not make a call.

The monitor then begins the waiting period, which lasts from the time the ratio is calculated (15 seconds after engine start) until 300 seconds after engine start. This 5-minute wait allows time to diagnose other components and systems that affect the validity of the catalyst temperature model. During this waiting period, there are no constraints on drive cycle and the monitor cannot be disabled without turning off the key.

At the end of the waiting period, if no other faults that could compromise the validity of the catalyst temperature model are found, the monitor compares the ratio to the threshold.

If the ratio exceeds the threshold, the monitor considers the test a fail, and the monitor is complete.

If the ratio falls below the threshold, and all of the component monitor results are below their respective thresholds, the monitor determines whether the idle time was sufficient. If so, it considers the test a pass and the monitor is complete. If idle time was not sufficient, the monitor does not make a pass call and does not complete. This prevents tip-ins from resulting in false passes.


ENGINE START
From 3 to 15 seconds
Increment timer if entry conditions are satisfied
Increment timer if idle state and gear state are satisfied
Observe actual and expected catalyst temperatures
Entry conditions satisfied for sufficient length of time? AND Expected change in catalyst temperature sufficient?
No
NO CALL
Yes
Calculate ratio
From 15 to 300 seconds
Check results of diagnosis of components and systems that are inputs to the catalyst temperature model
Is any fault that compromises the validity of the catalyst temperature model present?
Yes
NO CALL
No
Does ratio exceed threshold?
No
Was idle time sufficient?
No
NO CALL
Yes
Yes
FAIL Advance the state of P050E accordingly
PASS Advance the state of P050E accordingly

| CSER SYSTEM MONITOR OPERATION | |
|---|---|
| DTC | P050E: Cold Start Engine Exhaust Temperature Too Low |
| Monitor Execution | Once per driving cycle, during a cold start |
| Monitor Sequence | Monitor data collection takes place during first 15 seconds of cold start |
| Sensors OK | No fault is present in any of the sensors or systems affecting the catalyst temperature model: Mass Air Flow (P0102, P0103), Throttle Position (P0122, P0123, P0222, P0223), Misfire (P0316, P0300-P0312), Injectors (P0201-P0212), Fuel System (P0171, P0172, P0174, P0175), Secondary Air (P0412, P2258), Crank Position Sensor (P0320), Ignition Coil (P0351-P0360), Intake Air Temp (P0112, P0113), Engine Coolant Temp/Cylinder Head Temp (P0117, P0118, P1289, P1290), Variable Cam Timing (P0010, P0020, P0011, P0012, P0021, P0022), Intake Manifold Runner Control (P2008). |
| Monitoring Duration | Monitor completes 300 seconds after initial engine start |

| TYPICAL CSER SYSTEM MONITOR ENTRY AND COMPLETION CONDITIONS | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Barometric Pressure | 22 in. Hg | |
| Engine Coolant Temperature at Start | 35 °F | 100 °F |
| Catalyst Temperature at Start | 35 °F | 125 °F |
| Fuel Level | 15% | |
| No Torque Reduction by Injector Cutout | | |
| Power Takeout Not Active | | |
| Completion condition | Minimum | Maximum |
| Length of Time Entry Conditions are Satisfied | 11 sec. | |
| Expected Change in Catalyst Temperature | 50 °F | |
| Time in Idle | 10 sec. | |
| Selected Gear | Neutral | Drive |

| TYPICAL CSER SYSTEM MALFUNCTION THRESHOLD |
|---|
| Cold start warm-up temperature ratio > 0.2 |

## Variable Cam Timing System Monitor

Variable Cam Timing (VCT) enables rotation of the camshaft(s) relative to the crankshaft (phase-shifting) as a function of engine operating conditions. There are four possible types of VCT with DOHC engines:

- Intake Only (phase-shifting only the intake cam);
- Exhaust Only (phase-shifting only the exhaust cam);
- Dual Equal (phase-shifting the intake and exhaust cams equally);
- Dual Independent (phase-shifting the intake and exhaust cams independently).

All four types of VCT are used primarily to increase internal residual dilution at part throttle to reduce NOx, and to improve fuel economy. This allows for elimination the external EGR system.

With Exhaust Only VCT, the exhaust camshaft is retarded at part throttle to delay exhaust valve closing for increased residual dilution and to delay exhaust valve opening for increased expansion work.

With Intake Only VCT, the intake camshaft is advanced at part throttle and WOT (at low to mid-range engine speeds) to open the intake valve earlier for increased residual dilution and close the intake valve earlier in the compression stroke for increased power. When the engine is cold, opening the intake valve earlier warms the charge which improves fuel vaporization for less HC emissions; when the engine is warm, the residual burned gasses limit peak combustion temperature to reduce NOx formation.

With Dual Equal VCT, both intake and exhaust camshafts are retarded from the default, fully advanced position to increase EGR residual and improve fuel economy by reducing intake vacuum pumping losses. The residual charge for NOx control is obtained by backflow through the late-closing exhaust valve as the piston begins its intake stroke.

The VCT system hardware consists of a control solenoid and a pulse ring on the camshaft. The PCM calculates relative cam position using the CMP input to process variable reluctance sensor pulses coming from the pulse ring mounted on the camshaft. Each pulse wheel has N + 1 teeth where N = the number of cylinders per bank. The N equally spaced teeth are used for cam phasing; the remaining tooth is used to determine cylinder # 1 position. Relative cam position is calculated by measuring the time between the rising edge of profile ignition pickup (PIP) and the falling edges of the VCT pulses.

The PCM continually calculates a cam position error value based on the difference between the desired and actual position and uses this information to calculate a commanded duty cycle for the VCT solenoid valve. When energized, engine oil is allowed to flow to the VCT unit thereby advancing and retarding cam timing. The variable cam timing unit assembly is coupled to the camshaft through a helical spline in the VCT unit chamber. When the flow of oil is shifted from one side of the chamber to the other, the differential change in oil pressure forces the piston to move linearly along the axis of the camshaft. This linear motion is translated into rotational camshaft motion through the helical spline coupling. A spring installed in the chamber is designed to hold the camshaft in the low-overlap position when oil pressure is too low (~15 psi) to maintain adequate position control. The camshaft is allowed to rotate up to 30 degrees.

Although the VCT system has been monitored under Comprehensive Component Monitoring requirements for many years, a new, emission-based VCT monitor is being introduced for the 2006 MY on vehicles that meet LEV-II emission standards. The intent of the new VCT monitoring requirements is to detect slow VCT system response that could cause emissions to increase greater than 1.5 * std. in addition to detecting functional problems (target errors).

The new logic calculates the instantaneous variance in actual cam position (the squared difference between actual cam position and commanded cam position), then calculates the long term variance using a rolling average filter (Exponentially Weighted Moving Average). Continued, slow response from the VCT system will eventually accumulate large variances.

This same logic will also detect target errors that were detected by the previous CCM monitor. If the VCT system is stuck in one place, the monitor will detect a variance which will quickly accumulate.

There are three variance indices that monitor cam variance in the retard direction, the advance direction, and for V-engines, the difference between banks. If any variance index is greater than the malfunction threshold, a VCT slow response/target error malfunction will be indicated (P0011, P0012 Bank 1, 0021, P0022 Bank 2). Target errors will tend to generate only a single over-advanced or over-retarded code while slow response will tend to generate both codes.

In addition, logic has been added to determine whether the camshaft and crankshaft are misaligned by one or more teeth. This test calculates the absolute offset between one of the camshaft teeth and the crankshaft missing tooth at idle when that can is at its stop. If the error is greater than the malfunction threshold, a cam/crank misalignment error will be indicated (P0016 Bank 1, P0018 Bank 2).

For systems that phase the cams immediately off of a cold start for reducing emissions or CSER (Cold Start Emissions Reduction) the cam position is monitored for functionality during this period of time. There are two ways to set failures.

- Error between the actual position and the expected position is calculated. If the error is greater than a specified amount, and the Error persists for a period of time, a P052x code is set designating over advanced or retarded and the bank number. The diagnostic is only executed during CSER phasing.
- The diagnostic also checks for a cam position request above a threshold for a period of time, and determines that the VCT actuator pin is stuck if the cam does not move from the locked position by a certain amount. This is also only done during CSER operation. If the locking pin is determined to be stuck then the Oil Control Solenoid (OCS) is cycled on and off for a calibratable amount to allow pressure to build in the system to unseat the locking pin. If attempts to unstick the locking pin fail, then a P052x code is set.

The in-use performance ratio numerator for the VCT monitor can be incremented only if the VCT system has been monitored for both functional and response faults. If the vehicle is operated in a manner that does not ask the VCT actuators to change position, it may not be possible to evaluate whether they are working properly. As a result, the in-use ratio numerator checks to see if the commanded VCT position changes sufficiently to detect possible target errors and with a sufficiently high rate to detect possible slow response. For each drive cycle in which both criteria are met, the VCT in-use performance numerator will be incremented.

Similar to the previous CCM monitor, the VCT solenoid output driver in the PCM is checked electrically for opens and shorts (P0010 Bank 1, P0020 Bank 2).

| VCT Monitor Operation: | |
|---|---|
| DTCs | P0010 - Camshaft Position Actuator Circuit (Bank 1)<br><br>P0011 - Cam Position Actuator Over Advanced (Bank 1)<br><br>P0012 - Cam Position Actuator Over Retarded (Bank 1)<br><br>P0016 - Crank/Cam Position Correlation (Bank 1) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | IAT, ECT, EOT, IMRC, TP, MAF, CKP, and CMP |
| Monitoring Duration | 5 - 10 seconds for circuit faults and functional checks, 300 seconds for target error |

| Typical VCT response/functional monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine RPM (for P0016/P0018 only) | 850 | 4500 |
| Engine Coolant Temperature | 50 °F | |
| Engine Oil Temperature | | 280 °F |
| VCT control enabled and commanded to advance or retard cam ** | n/a | n/a |
| ** VCT control of advance and retard by the engine is disabled in crank mode, when engine oil is cold (< 150 °F), while learning the cam/crank offset, while the control system is "cleaning" the solenoid oil passages, throttle actuator control in failure mode, and if one of the following sensor failures occur: IAT, ECT, EOT, MAF, TP, CKP, CMP, or IMRC. | | |

| Typical VCT monitor malfunction thresholds: |
|---|
| VCT solenoid circuit: Open/short fault set by the PCM driver |
| Cam/crank misalignment: > or = 7.5 crank degrees |
| Response/target error - VCT over-advance variance too high: 100 degrees squared |
| Response/target error - VCT over-retard variance too high: 400 degrees squared |

| Typical In-Use Performance monitoring thresholds: |
|---|
| Monitoring thresholds to increment the numerator: |
| Amount of cam change required for target error fault: > 160 degrees squared |
| Amount of rate of change required for slow response fault: > 5 degrees squared |

| J1979 VCT Monitor Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | Units |
| $35 | $80 | Camshaft Advanced Position Error Bank 1 | Unsigned, Angular degrees |
| $35 | $81 | Camshaft Retarded Position Error Bank 1 | Unsigned, Angular degrees |

# Electronic Throttle Control

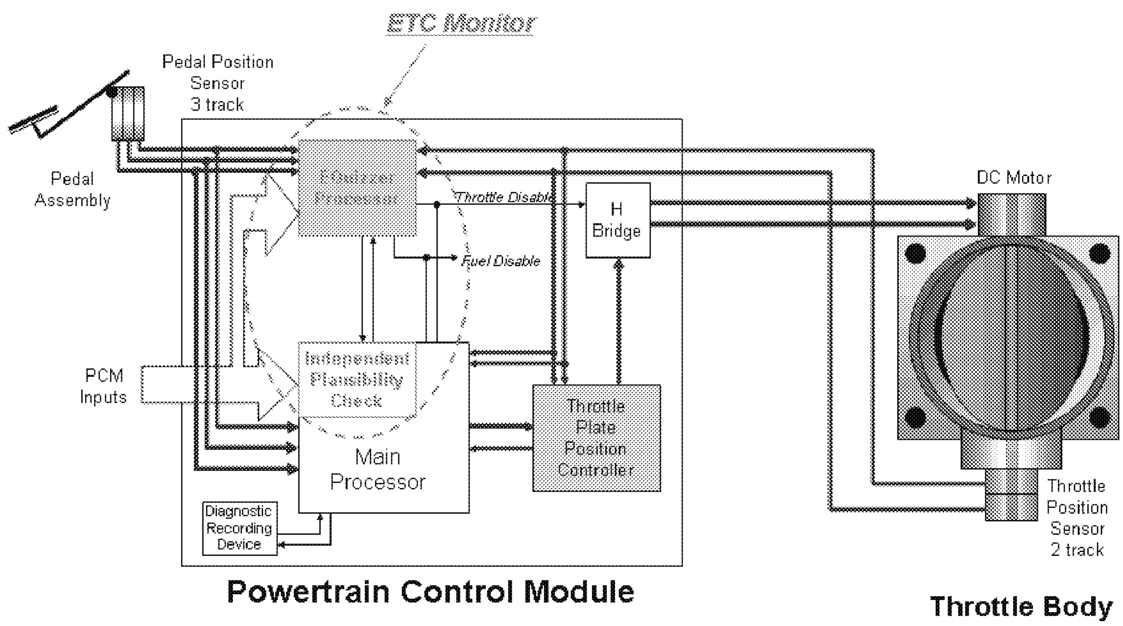
The Electronic Throttle Control (ETC) system uses a strategy that delivers engine or output shaft torque, based on driver demand, utilizing an electronically controlled throttle body. ETC strategy was developed mainly to improve fuel economy. This is possible by decoupling throttle angle (produces engine torque) from pedal position (driver demand). This allows the powertrain control strategy to optimize fuel control and transmission shift schedules while delivering the requested engine or wheel torque.

The Gen2 ETC system was first introduced in 2003MY Ford products. This system evolved into the Gen3 ETC system in 2008MY and the Gen4 ETC system in 2009MY. The Gen3 and Gen4 ETC systems made improvements over the Gen2 system by reducing complexity, improving reliability, and optimizing cost. The primary changes made for the Gen3 / Gen4 ETC systems were the following:

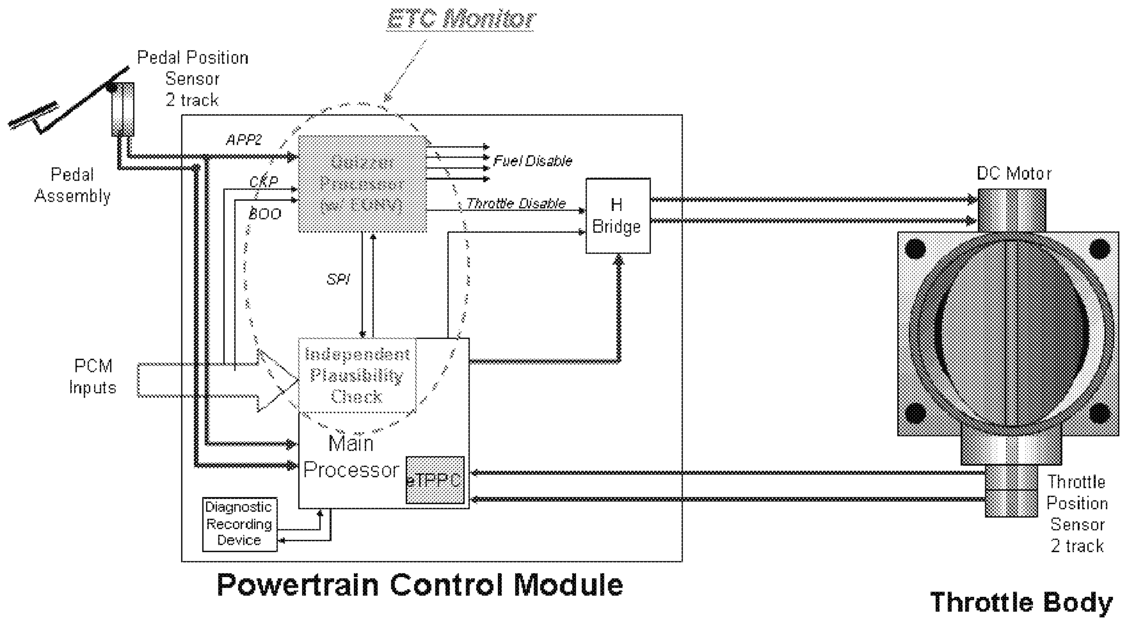
- Replace 3-track sensor Accelerator Pedal with 2-track sensor Accelerator Pedal.
- Introduce single plunger dual output brake switch.
- Integrate the Throttle Plate Position Controller (eTPPC) into the main processor within PCM.
- Reduce Quizzer complexity and integrate with the EONV function.

The Gen3 / Gen4 ETC systems have equivalent hardware systems with only software differences.

## Gen 2 ETC System



# Gen 3 / Gen 4 ETC System




Because safety is a major concern with ETC systems, a complex safety monitor strategy (hardware and software) was developed. The monitor system is distributed across two processors: the main powertrain control processor and a monitoring processor called a Quizzer processor.

The primary monitoring function is performed by the Independent Plausibility Check (IPC) software, which resides on the main processor. It is responsible for determining the driver-demanded torque and comparing it to an estimate of the actual torque delivered. If the generated torque exceeds driver demand by specified amount, the IPC takes appropriate mitigating action.

Since the IPC and main controls share the same processor, they are subject to a number of potential, common-failure modes. Therefore, the Quizzer processor was added to redundantly monitor selected PCM inputs and to act as an intelligent watchdog and monitor the performance of the IPC and the main processor. If it determines that the IPC function is impaired in any way, it takes appropriate Failure Mode and Effects Management (FMEM) actions.

| ETC System Failure Mode and Effects Management: | |
|---|---|
| Effect | Failure Mode |
| No Effect on Drivability | A loss of redundancy or loss of a non-critical input could result in a concern that does not affect driveability. The powertrain malfunction indicator (wrench) and the malfunction indicator lamp (MIL) do not illuminate, however the speed control may be disabled. A DTC is set to indicate the component or circuit with the concern. |
| Delayed APP Sensor Response with Brake Override | This mode is caused by the loss of one APP sensor input due to sensor, wiring, or PCM concerns. The system is unable to verify the APP sensor input and driver demand. The throttle plate response to the APP sensor input is delayed as the accelerator pedal is applied. The engine returns to idle RPM whenever the brake pedal is applied. The powertrain malfunction indicator (wrench) illuminates, but the MIL does not illuminate in this mode. An APP sensor related DTC is set. |
| LOS Supercreep | Loss of both APP sensor inputs due to sensor, wiring, or PCM concerns, or internal control mode torque performance, or generator speed or crankshaft position (CKP) sensor or harness. There is no response when the accelerator pedal is applied. The engine returns to idle RPM and driver demanded torque returns to zero whenever the brake pedal is applied. The powertrain malfunction indicator (wrench) illuminates, but the MIL does not illuminate in this mode. An internal control module torque performance or internal control module drive motor/generator/engine speed sensor or APP sensor DTC is set |
| LOS Supercreep | Creep mode is caused by the loss of one brake pedal position (BPP) and one APP sensor input. The system is unable to determine driver demand. There is no response when the accelerator pedal is applied. The powertrain malfunction indicator (wrench) illuminates, but the MIL does not illuminate in this mode. An APP and BPP sensor, or harness related DTC is set. |
| RPM Guard with Pedal Follower | In this mode, the throttle plate control is disabled due to the loss of both TP sensor inputs, loss of throttle plate control, stuck throttle plate, significant processor concerns, or other major electronic throttle body concern. The spring returns the throttle plate to the default (limp home) position. A maximum allowed RPM is determined based on the position of the accelerator pedal (RPM Guard). If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The powertrain malfunction indicator (wrench) and the MIL illuminate in this mode and a DTC for an ETC related component is set. EGR and VCT outputs are set to default values and speed control is disabled. |
| Shutdown | If a significant processor concern is detected, the monitor forces the vehicle to shutdown by disabling engine, generator and traction motor. The powertrain malfunction indicator (wrench), MIL, and hazard indicator may illuminate. |

## Transmission Range Sensor Inputs

| Transmission Range Sensor Check Operation: | |
|---|---|
| DTCs | P2800 – Transmission Range Sensor B Circuit (PRNDL input) (wrench light, non-MIL)<br>P2801 – Transmission Range Sensor B Circuit Range/Performance (wrench light, non-MIL)<br>P2802 – Transmission Range Sensor B Circuit Low (wrench light, non-MIL)<br>P2803 – Transmission Range Sensor B Circuit High (wrench light, non-MIL)<br>P2806 – Transmission Range Sensor Alignment (wrench light, non-MIL) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| Transmission range sensor check malfunction thresholds: | | | | | |
|---|---|---|---|---|---|
| TR Sensor | Park | Reverse | Neutral | Drive | Low |
| TR_A1 (VOLTS | 3.84 - 4.77 | 2.58 - 3.31 | 1.82 - 2.56 | 0.97 - 1.79 | 0.20 - 0.92 |
| TR_A2 (VOLTS | 0.20 - 1.08 | 1.56 - 2.25 | 2.26 - 2.96 | 2.97 - 3.74 | 3.77 - 4.45 |

| |
|---|
| Range/performance – disagreement between sensors > 3.85 degrees |

## Accelerator and Throttle Position Sensor Inputs

| On-demand KOEO / KOER Sensor Check Operation: | |
|---|---|
| DTCs | P1575 – APP out of self-test range (non-MIL) [Gen3 / Gen4 only] |
| Monitor execution | On-demand |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| Accelerator Pedal Position Sensor Check Operation: | |
|---|---|
| DTCs | P2122, P2123 – APP D circuit continuity (wrench light, non-MIL)<br>P2127, P2128 – APP E circuit continuity (wrench light, non-MIL)<br>P2138 – APP D/E circuit disagreement (wrench light, non-MIL) [Gen3 / Gen4 only] |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| APP sensor check malfunction thresholds: |
|---|
| Circuit continuity - Voltage < 0.25 volts or voltage > 4.75 volts<br>Range/performance – disagreement between sensors > 1.1 degrees |

| Throttle Position Sensor Check Operation: | |
|---|---|
| DTCs | P0122, P0123 – TP A circuit continuity (MIL, wrench light)<br>P0222, P0223 – TP B circuit continuity (MIL, wrench light)<br>P2135 – TP A / TP B correlation (non-MIL, wrench light) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| TP sensor check malfunction thresholds: |
|---|
| Circuit continuity - Voltage < 0.25 volts or voltage > 4.75 volts<br>Correlation and range/performance – disagreement between sensors > 7 degrees |

## Electronic Throttle Monitor

| Electronic Throttle Monitor Operation: | |
|---|---|
| DTCs | U0300 – ETC software version mismatch, IPC or Quizzer (MIL, Hazard, wrench light for Gen3 / Gen4)<br>P0600 – Serial Communication Link (MIL, Hazard, wrench light for Gen3 / Gen4)<br>P060A – Internal control module monitoring processor performance (MIL, Hazard, wrench light for Gen3 / Gen4)<br>P060B – Internal control module A/D processing performance (MIL, Hazard, wrench light)<br>P060C – Internal control module main processor performance (MIL, Hazard, wrench light)<br>P060D – Internal control module accelerator pedal performance (non-MIL) [Gen3 / Gen4 only]<br>P061A – Internal control module Torque Performance (MIL, wrench light)<br>P0A18 – Motor Torque Sensor Circuit Range/Performance (MIL, Hazard, wrench light)<br>P0A23 – Generator Torque Sensor Circuit Range/Performance (MIL, Hazard, wrench light)<br>P0C2F – Internal Control Module Drive Motor/Generator/Engine Speed Performance (MIL, wrench light)<br>P1A0D – Hybrid Powertrain Control Module – Generator Disabled (MIL, Hazard, wrench light)<br>P1A0E - Hybrid Powertrain Control Module – Motor Disabled (MIL, Hazard, wrench light)<br>P061F – Internal control module throttle actuator controller performance (non-MIL, wrench light for Gen3 / Gen4)<br>P1674 – Internal control module software corrupted (MIL, hazard, wrench light for Gen3 / Gen4) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

## Throttle Plate Position Controller (TPPC) Outputs

The purpose of the TPPC is to control the throttle position to the desired throttle angle. The Gen2 ETC system has a separate chip embedded in the PCM. The Gen3 / Gen4 ETC systems have the eTPPC function integrated in the main PCM processor.

For the stand alone TPPC, the desired throttle angle is communicated from the main CPU via a 312.5 Hz duty cycle signal. The TPPC interprets the duty cycle signal as follows:

0% <= DC < 4% - Out of range, limp home default position.

4% <= DC < 6% - Commanded default position, closed.

6% <= DC < 7% - Commanded default position. Used for key-on, engine off.

7% <= DC < 8% - Ice Breaker Mode.

8% <= DC < 10% - Closed against hard-stop. Used to learn zero throttle angle position (hard-stop) after key-up

10% <= DC <=92% - Normal operation, between 0 degrees (hard-stop) and 82%, 10% duty cycle = 0 degrees throttle angle, 92% duty cycle = 82 degrees throttle angle.

92% < DC <= 96% - Wide Open Throttle, 82 to 86 degrees throttle angle.

96% < DC <= 100% - Out of Range, limp home default position

The desired angle is relative to the hard-stop angle. The hard-stop angle is learned during each key-up process before the main CPU requests the throttle plate to be closed against the hard-stop. The output of the (e)TPPC is a voltage request to the H-driver (also in PCM). The H driver is capable of positive or negative voltage to the Electronic Throttle Body Motor.

| Throttle Plate Controller and Actuator Operation: | |
|---|---|
| DTCs | P2107 – processor test (MIL, wrench light)<br>P2111 – throttle actuator system stuck open (MIL, wrench light)<br>P2112 – throttle actuator system stuck closed (MIL, wrench light)<br>P2101 – throttle actuator range/performance test (MIL, wrench light)<br>P115E – throttle actuator airflow trim at max limit (MIL) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | < 5 seconds to register a malfunction |

## Engine Temperature Sensor Inputs

Analog inputs such as Intake Air Temperature (P0112, P0113), Cylinder Head Temperature (P1289. P1290), Mass Air Flow (P0102, P0103) and Throttle Position (P0122, P0123) are checked for opens, shorts, or rationality by monitoring the analog -to-digital (A/D) input voltage.

The ECT rationality test checks to make sure that ECT is not stuck high in a range that causes other OBD to be disabled. If after a long (6 hour) soak, ECT is very high (> 230 $^{o}$F) and is also much higher than IAT at start, it is assumed that ECT is stuck high. If after a long (6 hour) soak, ECT is stuck midrange between 175 $^{o}$F (typical thermostat monitor threshold temperature) and 230 $^{o}$F and is also much higher than IAT at start, it is assumed that ECT is stuck mid range.

| ECT Sensor Rationality Check Operation: | |
|---|---|
| DTCs | P0116 (ECT stuck high or midrange) |
| Monitor execution | Once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | ECT, CHT, IAT |
| Monitoring Duration | 100 seconds to register a malfunction |

| Typical ECT Sensor Rationality check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine-off time (soak time) | 360 min | |
| Difference between ECT and IAT | | 50 deg |
| Engine Coolant Temperature | 230 $^{o}$F | |
| Engine Coolant Temperature for stuck midrange condition | 160 $^{o}$F | 230 $^{o}$F |

| Typical ECT Sensor Rationality check malfunction thresholds: |
|---|
| Catalyst, Misfire, Fuel System or HO2S Monitors have not run this drive cycle |

The CHT sensor measures cylinder head metal temperature as opposed to engine coolant temperature. At lower temperatures, CHT temperature is equivalent to ECT temperature. At higher temperatures, ECT reaches a maximum temperature (dictated by coolant composition and pressure) whereas CHT continues to indicate cylinder head metal temperature. If there is a loss of coolant or air in the cooling system, the CHT sensor will still provides an accurate measure of cylinder head metal temperature. If a vehicle uses a CHT sensor, the PCM software calculates both CHT and ECT values for use by the PCM control and OBD systems.

| **Cylinder Head Temperature Sensor Check Operation:** | |
|---|---|
| DTCs | P1289 (high input), P1290 (low input), P1299 (fail-safe cooling activated) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| **Typical CHT sensor check malfunction thresholds:** |
|---|
| Voltage < 0.41 volts or voltage > 4.95 volts<br>For P1299, MIL illuminates immediately if CHT > 270 ° Fuel shut-off is activated to reduce engine and coolant temperature |

| **Intake Air Temperature Sensor Check Operation:** | |
|---|---|
| DTCs | P0112 (low input), P0113 (high input) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| **Typical IAT sensor check malfunction thresholds:** |
|---|
| Voltage < 0.20 volts or voltage > 4.93 volts |

| ECT, IAT, EOT Temperature Sensor Transfer Function | | |
|---|---|---|
| **Volts** | **A/D counts in PCM** | **Temperature, degrees F** |
| 4.89 | 1001 | -40 |
| 4.86 | 994 | -31 |
| 4.81 | 983 | -22 |
| 4.74 | 970 | -13 |
| 4.66 | 954 | -4 |
| 4.56 | 934 | 5 |
| 4.45 | 910 | 14 |
| 4.30 | 880 | 23 |
| 4.14 | 846 | 32 |
| 3.95 | 807 | 41 |
| 3.73 | 764 | 50 |
| 3.50 | 717 | 59 |
| 3.26 | 666 | 68 |
| 3.00 | 614 | 77 |
| 2.74 | 561 | 86 |
| 2.48 | 508 | 95 |
| 2.23 | 456 | 104 |
| 1.99 | 407 | 113 |
| 1.77 | 361 | 122 |
| 1.56 | 319 | 131 |
| 1.37 | 280 | 140 |
| 1.20 | 246 | 149 |
| 1.05 | 215 | 158 |
| 0.92 | 188 | 167 |
| 0.80 | 165 | 176 |
| 0.70 | 144 | 185 |
| 0.61 | 126 | 194 |
| 0.54 | 110 | 203 |
| 0.47 | 96 | 212 |
| 0.41 | 85 | 221 |
| 0.36 | 74 | 230 |
| 0.32 | 65 | 239 |
| 0.28 | 57 | 248 |
| 0.25 | 51 | 257 |
| 0.22 | 45 | 266 |
| 0.19 | 40 | 275 |
| 0.17 | 35 | 284 |
| 0.15 | 31 | 293 |
| 0.14 | 28 | 302 |

## IAT Rationality Test

The IAT rationality test determines if the IAT sensor is producing an erroneous temperature indication within the normal range of IAT sensor input.

The IAT sensor rationality test is run only once per power-up. The IAT sensor input is compared to the CHT sensor input (ECT sensor input on some applications) at key-on after a long (6 hour) soak. If the IAT sensor input and the CHT (ECT) sensor input agree within a tolerance (+/- 30 deg F), no malfunction is indicated and the test is complete. If the IAT sensor input and the CHT (ECT) sensor input differ by more than the tolerance, the vehicle must be driven over maximum electric vehicle speed for 5 minutes to confirm the fault. This is intended to address noise factors like sun load that can cause the IAT sensor to indicate a much higher temperature than the CHT (ECT) sensor after a long soak. Driving the vehicle attempts to bring the IAT sensor reading within the test tolerance. If the IAT sensor input remains outside of the tolerance after the vehicle drive conditions have been met, the test indicates a malfunction and the test is complete.

In addition to the start-up rationality check, an IAT "Out of Range" check is also performed. The test continuously, checks to see if IAT is greater than the “IAT Out of Range High threshold”, approximately 150 deg F. In order to prevent setting false DTC during extreme ambient or vehicle soak conditions, the same count up/count down timer used for the IAT startup rationality test is used to validate the fault. If IAT is greater than 150 deg F and vehicle speed is greater than ~ 40 mph for 250 seconds then set a P0111.

Either the IAT startup rationality test or the IAT Out of Range High test can set a P0111 DTC. The logic is designed so that either fault can trigger a P0111, however, both faults must be OK before the P0111 DTC is cleared.

Block heater detection results in a no-call.

| Intake Air Temperature Sensor Range/Performance Check Operation: | |
|---|---|
| DTCs | P0111 (range/performance) |
| Monitor execution | Once per driving cycle, at start-up |
| Monitor Sequence | None |
| Sensors OK | ECT/CHT, IAT, VSS |
| Monitoring Duration | Immediate or up to 30 minutes to register a malfunction |

| Typical Intake Air Temperature Sensor Range/Performance Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Air Mass | 1.2 lbm/min | |
| Engine off (soak) time | 6 hours | |
| Battery Voltage | 11.0 Volts | |
| Time since engine start (if driving req'd) | | 30 min |
| Vehicle speed (if driving req'd) | 35 mph | |
| Time above minimum vehicle speed (if driving req'd) | 5 min | |
| IAT - ECT at start (block heater inferred) | -30 °F | -90 °F |

| Typical IAT sensor check malfunction thresholds: |
|---|
| IAT and ECT/CHT error at start-up > +/-30 deg F |

| Intake Air Temperature Sensor Out of Range High Check Operation: | |
|---|---|
| DTCs | P0111 (Out of Range High) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ECT/CHT, IAT, VSS |
| Monitoring Duration | 250 seconds to register a malfunction |

| Typical Intake Air Temperature Sensor Out of Range high Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine off (soak) time | 6 hours | |
| Battery Voltage | 11.0 Volts | |
| Vehicle speed | 35 mph | |
| Time above minimum vehicle speed (if driving req'd) | 5 min | |
| | | |

| Typical IAT Sensor Out of Range High check malfunction thresholds: |
|---|
| IAT > 150 deg F |

## Throttle Position Sensor

| Throttle Position Sensor Check Operation: | |
|---|---|
| DTCs | P0122 (low input), P0123 (high input) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical TP sensor check malfunction thresholds: |
|---|
| Voltage < 0.20 volts or voltage > 4.80 volts |

## Mass Air Flow Sensor

| MAF Sensor Check Operation: | |
|---|---|
| DTCs | P0102 (low input), P0103 (high input) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical MAF sensor check malfunction thresholds: |
|---|
| Voltage < 0.244 volts and engine running or voltage > 4.785 volts engine rpm < 4,000 rpm |

## MAF/TP Rationality Test

The MAF and TP sensors are cross-checked to determine whether the sensor readings are rational and appropriate for the current operating conditions. (P1A0C)

| MAF/TP Rationality Check Operation: | |
|---|---|
| DTCs | P1A0C |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 5 seconds within test entry conditions |

| Typical MAF/TP rationality check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine RPM | 1025 rpm | minimum of 3800 rpm |
| Engine Coolant Temp | 40 °F | |

| Typical MAF/TP rationality check malfunction thresholds: |
|---|
| Load > 55% and TP < 0.288 volts or Load < 20% and TP > 1.953 volts |

| 5 Volt Sensor Reference Voltage Check: | |
|---|---|
| DTCs | P0642 (low input), P0643 (high input) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical sensor check malfunction thresholds: |
|---|
| Voltage < 4.5 volts or voltage > 5.5 volts |

## Miscellaneous CPU Tests

Loss of Keep Alive Memory (KAM) power (a separate wire feeding the PCM) results is a P1633 DTC and immediate MIL illumination on most applications.

Vehicles that require tire/axle information and VIN to be programmed into the PCM Vehicle ID block (VID) will store a P1639 if the VID block is not programmed or corrupted.

Additional DTCs will be stored to indicate various internal PCM hardware malfunctions:

P0602 - Powertrain Control Module Programming Error indicates that the Vehicle ID block check sum test failed.

P0603 - Powertrain Control Module Keep Alive Memory (KAM) Error indicates the Keep Alive Memory check sum test failed.

P0604 - Powertrain Control Module Random Access Memory (RAM) Error indicates the Random Access Memory read/write test failed.

P0605 - Powertrain Control Module Read Only Memory (ROM) Error indicates a Read Only Memory check sum test failed.

P0607 - Powertrain Control Module Performance indicates incorrect CPU instruction set operation, or excessive CPU resets.

P068A - ECM/PCM Power Relay De-energized - Too Early. This fault indicates that NVRAM write did not complete successfully after the ignition key was turned off, prior to PCM shutdown.

P06B8 - Internal Control Module Non-Volatile Random Access Memory (NVRAM) Error indicates Permanent DTC check sum test failed

The PCM "engine off" or "soak" timer is tested to ensure that it is functional. The value of engine coolant temperature decays after the engine is turned off. This decay is modeled as a function of ECT, IAT and soak time. If, during a cold start, (difference between ECT and IAT is low), the actual ECT at start is much lower than the predicted ECT at start, it means that the soak timer is not functioning and a P2610 DTC is stored. (If the timer fails, it will read zero seconds and the model will predict that ECT will be the same temperature as when the engine was last turned off.)

U0101 – Lost Communication With TCM

| 5 Volt Sensor Reference Voltage A Check: | |
|---|---|
| DTCs | P0642 (low input)<br>P0643 (high input) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 sec to register a malfunction |

| Typical 5 Volt Sensor Reference Voltage A & B check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition "ON" | NA | NA |

| Typical 5 Volt Sensor Reference Voltage A & B check malfunction thresholds: |
|---|
| P0642<br>Short to ground (signal voltage): < 4.75 V<br>P0643<br>Short to battery plus (signal voltage): > 5.25 V |

## Ignition

New floating point processors no longer use an EDIS chip for ignition signal processing. The crank and cam position signals are now directly processed by the PCM/ECM microprocessor using a special interface chip called a Time Processing Unit or TPU. The 36-tooth crankshaft and camshaft position signals come directly into the TPU. The signals to fire the ignition coil drivers also come from the TPU.

The ignition system is checked by monitoring three ignition signals during normal vehicle operation:

> CKP, the signal from the crankshaft 60-2-tooth wheel. The missing teeth are used to locate the cylinder pair associated with cylinder # 1 The TPU also generates the Profile Ignition Pickup (PIP) signal, a 50% duty cycle, square wave signal that has a rising edge at 10 deg BTDC.
>
> Camshaft Position (CMP), a signal derived from the camshaft to identify the #1 cylinder

First, several relationships are checked on the 60-2 tooth CKP signal. The TPU looks for the proper number of teeth (58) after the missing teeth are recognized; time between teeth too low (< 30 rpm or > 9,000 rpm); or the missing teeth were not where it was expected to be. If an error occurs, the TPU shuts off fuel and the ignition coils and attempts to resynchronize itself. It takes on revolution to verify the missing tooth, and another revolution to verify cylinder #1 using the CMP input. Note that if a P0320 DTC is set on a vehicle with Electronic Throttle Control, (ETC), the ETC software will also set a P2106.

If the proper ratio of CMP events to PIP events is not being maintained (for example, 1 CMP edge for every 8 PIP edges for an 8-cylinder engine), it indicates a missing or noisy CMP signal (P0340). On applications with Variable Cam Timing (VCT), the CMP wheel has five teeth to provide the VCT system with more accurate camshaft control. The TPU checks the CMP signal for an intermittent signal. If an intermittent is detected, the VCT system is disabled and a P0344 (CMP Intermittent Bank 1) or P0349 (CMP intermittent Bank 2) is set.

| CKP Ignition System Check Operation: | |
|---|---|
| DTCs | P0320 - Ignition Engine Speed Input Circuit |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | |
| Monitoring Duration | < 5 seconds |

| Typical CKP ignition check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine RPM for CKP | 200 rpm | |

| Typical CKP ignition check malfunction thresholds: |
|---|
| Incorrect number of teeth after the missing tooth is recognized,<br>Time between teeth too low (< 30 rpm or > 9,000 rpm)<br>Missing tooth was not where it was expected to be. |

| CMP Ignition System Check Operation: | |
|---|---|
| DTCs | P0340 - Intake Cam Position Circuit, Bank 1 |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | |
| Monitoring Duration | < 5 seconds |

| Typical CMP ignition check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine RPM for CMP | 200 rpm | |

| Typical CMP ignition check malfunction thresholds: |
|---|
| Ratio of PIP events to CMP events: 4:1, 6:1, 8:1 or 10:1 based on engine cyl |

| Coil Primary Ignition System Check Operation: | |
|---|---|
| DTCs | P0351 – P0354 (Coil primary) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 5 seconds |

| Typical Coil primary ignition check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine RPM for coil primary | 200 rpm | Minimum of 3200 rpm |
| Positive engine torque | Positive torque | |
| Battery Voltage | 11 volts | 16 volts |

| Typical Coil primary ignition check malfunction thresholds: |
|---|
| Ratio of PIP events to IDM or NOMI events 1:1 |

## Engine Outputs

The PCM will monitor the "smart" driver fault status bit that indicates either an open circuit, short to power or short to ground.

| Injector Check Operation: | |
|---|---|
| DTCs | P0201 through P0204 (opens/shorts) |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Monitoring Duration | 10 seconds |

| Typical injector circuit check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 11.0 volts | |
| Engine Coolant Temp | | 240 $^{o}$F |
| Intake Air Temp | | 150 $^{o}$F |

The Idle Air Control is functionally checked by monitoring the closed loop idle speed correction required to maintain the desired idle rpm. If the proper idle rpm cannot be maintained and the system has a high rpm (+100) or low rpm error (-200) greater than the malfunction threshold, an IAC malfunction is indicated. (P0507, P0506)

| IAC Check Operation: | |
|---|---|
| DTCs | P0507 (functional - overspeed)<br>P0506 (functional - underspeed) |
| Monitor execution | once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 15 seconds |

| Typical IAC functional check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Coolant Temp | 130 $^{o}$F | |
| Time since engine start-up | 100 seconds | |
| Closed loop fuel | Yes | |
| Throttle Position (at idle, closed throttle, no dashpot) | Closed | Closed |

| Typical IAC functional check malfunction thresholds: |
|---|
| For underspeed error: Actual rpm 100 rpm below target, closed-loop IAC correction > 1 lb/min<br>For overspeed error: Actual rpm 200 rpm above target, closed-loop IAC correction < .2 lb/min |

## Mechanical Returnless Fuel System (MRFS) — Dual Speed

The FP signal is a duty cycle command sent from the PCM to the fuel pump control module. The fuel pump control module uses the FP command to operate the fuel pump at the speed requested by the PCM or to turn the fuel pump off. A valid duty cycle to command the fuel pump on, is in the range of 15-47%. The fuel pump control module doubles the received duty cycle and provides this voltage to the fuel pump as a percent of the battery voltage. When the ignition is turned on, the fuel pump runs for about 1 second and is requested off by the PCM if engine rotation is not detected.

**FUEL PUMP DUTY CYCLE OUTPUT FROM PCM**

| FP Duty Cycle Command | PCM Status | Fuel Pump Control Module Actions |
|---|---|---|
| 0-15% | Invalid off duty cycle | The fuel pump control module sends a 20% duty cycle signal on the fuel pump monitor (FPM) circuit. The fuel pump is off. |
| 37% | Normal low speed operation. | The fuel pump control module operates the fuel pump at the speed requested. The fuel pump control module sends a 60% duty cycle signal on FPM circuit. |
| 47% | Normal high speed operation. | The fuel pump control module operates the fuel pump at the speed requested. The fuel pump control module sends a 60% duty cycle signal on FPM circuit. |
| 51-67% | Invalid on duty cycle. | The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is off. |
| 67-83% | Valid off duty cycle | The fuel pump control module sends a 60% duty cycle signal on FPM circuit. The fuel pump is off. |
| 83-100% | Invalid on duty cycle. | The fuel pump control module sends a 20% duty cycle signal on the FPM circuit. The fuel pump is off. |

The fuel pump control module communicates diagnostic information to the PCM through the FPM circuit. This information is sent by the fuel pump control module as a duty cycle signal. The 4 duty cycle signals that may be sent are listed in the following table.

**FUEL PUMP CONTROL MODULE DUTY CYCLE SIGNALS**

| Duty Cycle | Comments |
|---|---|
| 20% | This duty cycle indicates the fuel pump control module is receiving an invalid duty cycle from the PCM. |
| 40% | For vehicles with event notification signal, this duty cycle indicates the fuel pump control module is receiving an invalid event notification signal from the RCM. For vehicles without event notification signal, this duty cycle indicates the fuel pump control module is functioning normally. |
| 60% | For vehicles with event notification signal, this duty cycle indicates the fuel pump control module is functioning normally. |
| 80% | This duty cycle indicates the fuel pump control module is detecting a concern with the secondary circuits. |

| MRFS Check Operation: | |
|---|---|
| DTCs | P025A – Fuel Pump Control Circuit (opens/shorts)<br>P025B – Invalid Fuel Pump Control Data (20% duty cycle from FPM)<br>P0627 – Fuel Pump Secondary Circuit (80% duty cycle from PFM)<br>U2010B – Fuel Pump Disabled Circuit (40% duty cycle from FPM)<br>U0109 – Loss of Communication with Fuel Pump Module |
| Monitor execution | once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 2 seconds |

| Typical MRFS check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 11 volts | |

| Typical MRFS check malfunction thresholds: |
|---|
| P025A<br>FP output driver indicates fault<br>P025B, P0627, U210B<br>Fuel Pump Monitor duty cycle feedback of 20, 40 or 80%<br>U0191<br>No Fuel Pump Monitor duty cycle feedback |

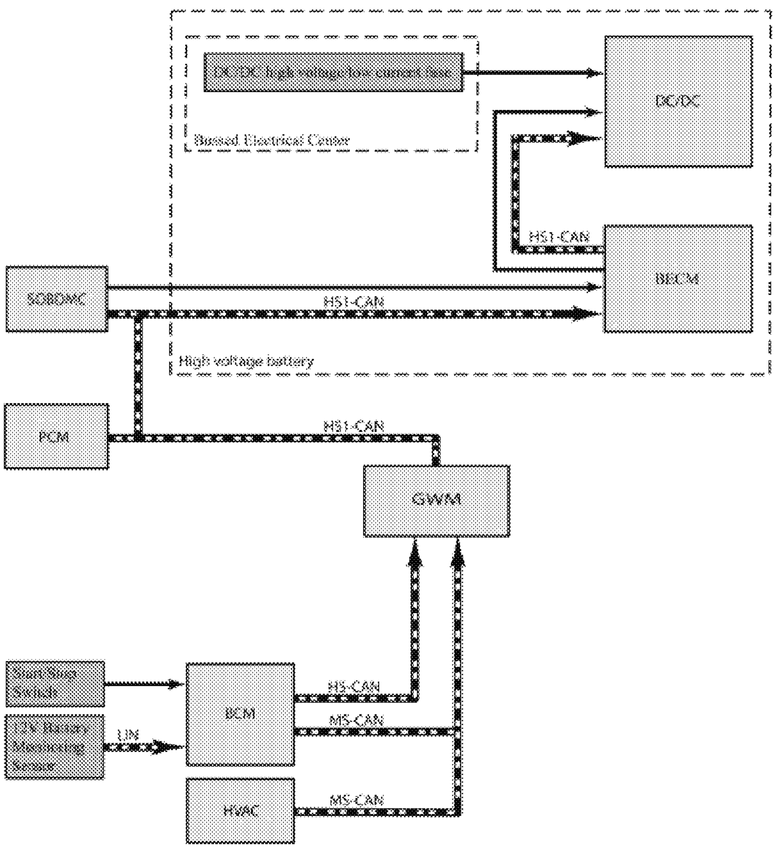
[redacted]

## Low Voltage Battery Charging System - Overview

The 12V battery is charged by the Direct Current/Direct Current (DC/DC) converter control module. It is enabled when the high voltage battery contactors have closed, providing high-voltage power to the DC/DC converter control module.

The Battery Monitoring Sensor continuously monitors the battery state of charge condition and provides the BCM with this information. The BCM communicates this information to the PCM over the High Speed CAN network (HS-CAN). The PCM communicates the battery desired set point to the DC/DC converter control module which supplies the necessary charge voltage to the 12V battery. The Battery Monitoring Sensor also estimates losses in the battery capacity over time. The Battery Monitoring Sensor should only be reset when the battery is replaced.

The Battery Monitoring Sensor is clamped directly to the negative terminal of the battery and grounds to the vehicle at the chassis ground connection point through the negative battery cable and eyelet. It is part of the negative battery cable and cannot be serviced separately.




E155478

The PCM monitors the low voltage battery for charging performance.

| Low Voltage Battery Check Operation: | |
|---|---|
| DTCs | P057F - Battery State of Charge Performance. |
| Monitor execution | During vehicle / engine off while on plug-in charge |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | |

| Low Voltage Battery check malfunction thresholds: |
|---|
| Low Voltage Battery current / time > 6 amps / 60 min<br>Low Voltage Battery temperature gradient too high, gradient counter > 3<br>Low Voltage Battery temperature.> 140 deg F |

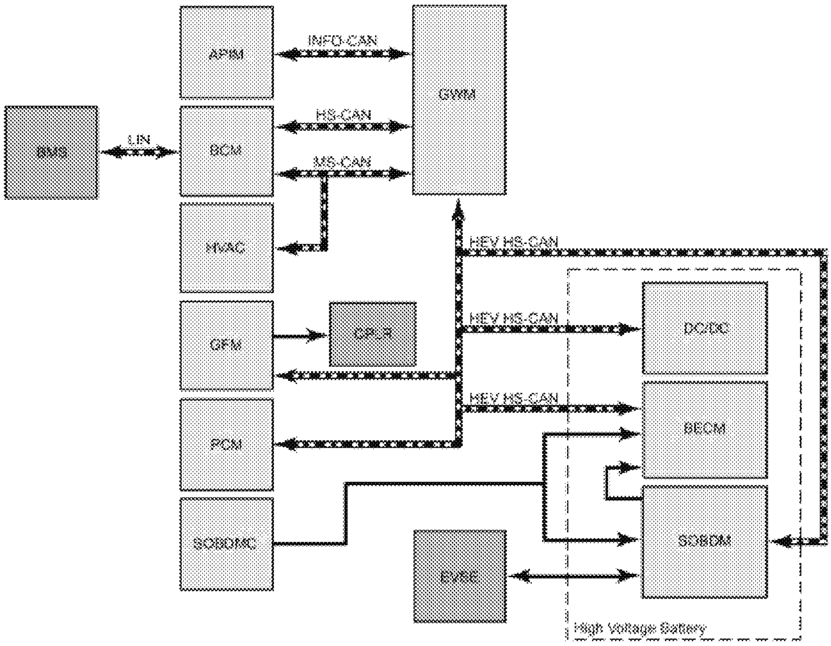
## High Voltage Battery Charging System - Overview

The high voltage battery charging system is responsible for charging the high voltage battery while the vehicle is not operating. It consists of an Electric Vehicle Supply Equipment (EVSE), Secondary OBD Module (also known as the Battery Changer Control Module and Charge Port Light Ring (CPLR).

The EVSE is an external AC charger that connects to an external voltage source and the vehicle charge port when the vehicle is not operating to charge the high voltage battery. The 110V (AC Level 1) charger and cord set plugs into a standard 110V AC outlet and comes with the vehicle when purchased. The 110V charger is rated up to 12 amps or up to 16 amps depending on the household receptacle being used. It is recommended to use a dedicated 110V electrical outlet to ensure adequate current supply for charging. A 220V (AC Level 2) charging station can also be utilized which is rated up to 80 amps.

The SOBDM, also known as the Battery Charger Control Module (BCCM), is an air-cooled component that charges both the high voltage battery and the low voltage (12V) battery when the vehicle is not operating and plugged into a (110V or 220V) EVSE. The SOBDM is known as the on-board charger. Its primary function is to coordinate charging operations and convert AC to DC. The SOBDM incorporates an integrated module that communicates with other modules over the HS-CAN, and is located inside the high voltage battery pack electronics compartment.

When the EVSE is plugged into the vehicle charging port, the CPLR indicates the current Customer State-of-Charge (CSoC) and charging operations of the high voltage battery. The CPLR is a light ring surrounding the charge port inlet that displays charging, charging faults and charging status using four LED light segments.

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The SOBDM, also known as the BCCM (Battery Charger Control Module), charges the high voltage battery and has an internal DC to DC Converter Control Module to maintain the 12V battery while vehicle is plugged into an external 110V or 220V AC EVSE. The SOBDM is an air-cooled component that converts an input voltage of (120 or 240 volts) AC to high-voltage DC and low-voltage DC power, while maintaining electrical isolation between the systems. When plugged into an external power source the SOBDM is enabled and charges the high voltage battery (168-361 volts) and the low-voltage battery (12-15 volts). The SOBDM steps the high-voltage down to a low-voltage (between 12 and 15 volts, depending on vehicle needs), providing power to charge the vehicle low-voltage battery. During charge the SOBDM incorporates an internal DC/DC converter to charge the low-voltage battery directly.

When the EVSE cord is plugged in the SOBDM wakes up by sensing a control pilot signal. The pilot signal duty cycle is analyzed to determine AC line capacity and the frequency is monitored to make sure it is in the proper range. The EVSE monitors the pilot signal to determine when to turn on AC output. A separate proximity circuit signal is analyzed to confirm if the connection is stable and the S3 button on the external charger cord is released. If both signals are in correct range, the SOBDM transmits an on-plug message via HEV HS-CAN. The SOBDM confirms the gear position is in park and that the vehicle is not in torque producing mode via HEV HS-CAN and closes an internal S2 switch signaling the EVSE to send AC voltage to the SOBDM. The high voltage system does not charge if the gear position is is not in park or if the vehicle is started.

Switch S2 detection is determined by the pilot signal voltage change. If the AC voltage input is within range the SOBDM enables 12V battery charging and wakes up the BECM. While waiting to enter high voltage charging state, the SOBDM sets low voltage output to a minimum of 12.6V until it receives a low-voltage setpoint from the PCM via HEV HS-CAN. The SOBDM is ready for high voltage power conversion when it transmits a charger-ready message via the HEV HS-CAN.

The SOBDM internally transitions from a ready state to charging state of the high voltage battery upon receipt of a battery charge ready or charging message from the BECM via the HEV HS-CAN. When the BECM status goes from a charge ready to a charging state the charge contactors are closed to begin charging the high voltage battery. The SOBDM limits the voltage and current to the high voltage battery based on the maximum voltage and current requests from the BECM via the HEV HS-CAN. The SOBDM transmits high voltage and current output internal measurements to the BECM via the HEV HS-CAN.

During high voltage charging the BECM commands the outside air (OSA) duct mode door actuator to open. This allows outside air to be pulled into the High Voltage Battery pack to cool SOBDM. The BECM monitors the mode door position and motor circuits and sets a DTC if a fault is detected. The SOBDM monitors its internal temperature and commands the charger cooling fan speed accordingly to prevent overheating. When high-voltage charging is complete the BECM charging state HEV HS-CAN message switches from charging to charging complete and opens the high voltage charge contactors. The SOBDM continues to charge the 12V battery while AC input is present except when commanded off by the SOBDMC.

During high 12V electrical loads or if the ignition is turned on while the vehicle is plugged in the main DC to DC Converter Control Module is enabled to charge the 12V battery. If this occurs, the SOBDM disables its low-voltage support and no longer charges the 12V battery. However, it continues charging the high voltage battery. The SOBDM shuts down if the PCM no longer requests low-voltage support and the BECM status is charge complete.

If the release button (S3) on the EVSE is pressed while low-voltage or high-voltage charging is in progress, the SOBDM detects a change of proximity circuit voltage. The high-voltage and the low-voltage DC charging simultaneously stops. The SOBDM disables power conversion and opens the internal S2 switch. When the EVSE detects an open S2 switch by sensing a pilot signal voltage change, it drops the AC voltage output to zero so the charger cord can be safely removed. This prevents arcing of the charge port terminals when the EVSE cord is disconnected.

The CPLR displays the current CSoC and charging operations of the high voltage battery. When plugged into an external power source (120 or 240 volts), the CPLR activates the light ring around the charge inlet port and performs a cord acknowledgment. If successful, this sequence flashes one light segment one at a time in order. The segments shut off and this sequence repeats 2 times. The CPLR displays charging, charging faults, and charging status. The light ring is segmented into 4 equal LEDs, each indicating the state of charge: • One segment flashing < 25% charged • One segment lit (one segment flashing) > 25% charged • Two segments lit (one segment flashing) > 50% charged • Three segments lit (one segment flashing) > 75% charged. A flashing ring segment indicates a charge is in progress. When all four rings are solidly lit, the charging operation is complete. If less than four rings are lit solid charging is not ready. When the charge is complete an internal timer starts to do a 3-5 minute shutoff to turn the LEDs off and put the module to sleep. The LEDs remain off until a Puddle Light Activation command is sent via the key fob or door handle. If there is a fault, all LED segments flash rapidly for no more than 5 minutes before going to sleep. LEDs illumination varies depending if it is daytime or nighttime.

To remove the EVSE cord press the release button to stop the charging process. All the LEDs shut off indicating it is safe to unplug the cord. There is a customer preference setting in the APIM to customize the operation of the CPLR. The options available include: 1. LEDs On (normal operation) 2. LEDs Off except for Cord Acknowledgements and Puddle Light Activation requests, 3. LEDs Off (this setting prevents LED operation for any reason).

| Battery Charge Control Module Performance Check Operation: | |
|---|---|
| DTCs | P0D24 - Battery Charger Temperature Too High<br>P0562 - System Voltage Low<br>P0DAA - Battery Charging System Isolation Fault |
| Monitor execution | Charger active, on-plug, connected to EVSE and charging |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 60 sec |

| Battery Charge Control Module Performance malfunction thresholds: |
|---|
| P0D24 - Internal temperature too high<br>P0562 - < 10.5V DC for 60 sec measured at charger B+ terminal<br>P0DAA - The measured leakage voltage is used to calculate the resistance between each high voltage bus and chassis < 41 kohm when charge contactors are closed. |

| Battery Charge Control Module Functional Check Operation: | |
|---|---|
| DTCs | P0D59 - Proximity Detection Circuit High.<br>P0D80 - Battery Charger Input Circuit/Open. |
| Monitor execution | P0D59: Charger is ON, PSR applied or active EVSE connected<br>P0D80: On-Plug, EVSE active. connected to EVSE , and S2 closed |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 60 sec |

| Battery Charge Control Module Functional malfunction thresholds: |
|---|
| P0D59 - EVSE proximity circuit detected open. Proximity circuit detected >4.8V DC for 5 seconds.<br>P0D80 – A/C Utility input not present after EVSE S2 switch closed. A/C Input voltage < 85 VAC for 30 seconds. |

| Battery Charge Control Module Performance Check Operation: | |
|---|---|
| DTCs | P0D67 - Battery Charger Control Module Performance. |
| Monitor execution | Charger active; connected to EVSE, S2 closed, and utility A/C is present to charger input |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 60 sec |

| Battery Charge Control Module Performance malfunction thresholds: |
|---|
| Internal on-board charger module fault detected that prevents charging functionality. Failure conditions include:<br>Low Voltage circuit overvoltage, High Voltage circuit overvoltage, PFC failure, High Voltage circuit voltage or current control circuit fault, High Voltage circuit current sensor failure. |

| Battery Charging System Contactor Check Operation: | |
|---|---|
| DTCs | P0D0F - Battery Charging System Negative Contactor Stuck Closed<br>P0D09 - Battery Charging System Positive Contactor Stuck Open |
| Monitor execution | |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1sec |

| Battery Charging System Contactor malfunction thresholds: |
|---|
| P0D0F - Negative charge contactor status remains closed. Contactor measurement voltage reported over CAN to the BECM is >= (pack voltage - 20v) When charge negative contactor is being commanded from close to open.<br>P0D09 - Charge positive contactor reported charger voltage over CAN to the BECM is > +/- 5% of Pack voltage AND the reported charger current over CAN to the BECM is < 0.5 amps AND both charge contactors are commanded closed AND both charge contactors have power when charge positive contactor is closed. |

| Battery Charging System Contactor Check Operation: | |
|---|---|
| DTCs | P0D0A - Battery Charging System Positive Contactor Control Circuit/Open<br>P0D0D - Battery Charging System Positive Contactor Control Circuit High<br>P0D0B - Battery Charging System Positive Contactor Control Circuit Range/Performance<br>P0D14 - Battery Charging System Negative Contactor Control Circuit High |
| Monitor execution | |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1sec |

| Battery Charging System Contactor malfunction thresholds: |
|---|
| P0D0A - Charge positive contactor reported charger voltage over CAN to the BECM is > +/- 5% of Pack voltage AND the reported charger current over CAN to the BECM is < 0.5 amps AND both charge contactors are commanded closed AND one or both charge contactors DO NOT have power when charge positive contactor is closed.<br>P0D0D - Charge positive contactor low side driver in limited current mode.<br>P0D0B - Charge contactor high side driver in overcurrent mode when any charge contactor is closed.<br>P0D14 - Charge negative contactor low side driver in limited current mode. |

## High Voltage Battery - Overview

The plug in hybrid can be used as an electric vehicle, conventional hybrid vehicle, or both. The high voltage battery on the plug in hybrid application has more capacity than a full hybrid application and can be fully charged using EVSE (Electric Vehicle Supply Equipment) connected to the vehicle charge port. An EV button is located on the steering wheel to change the vehicle operating strategy.

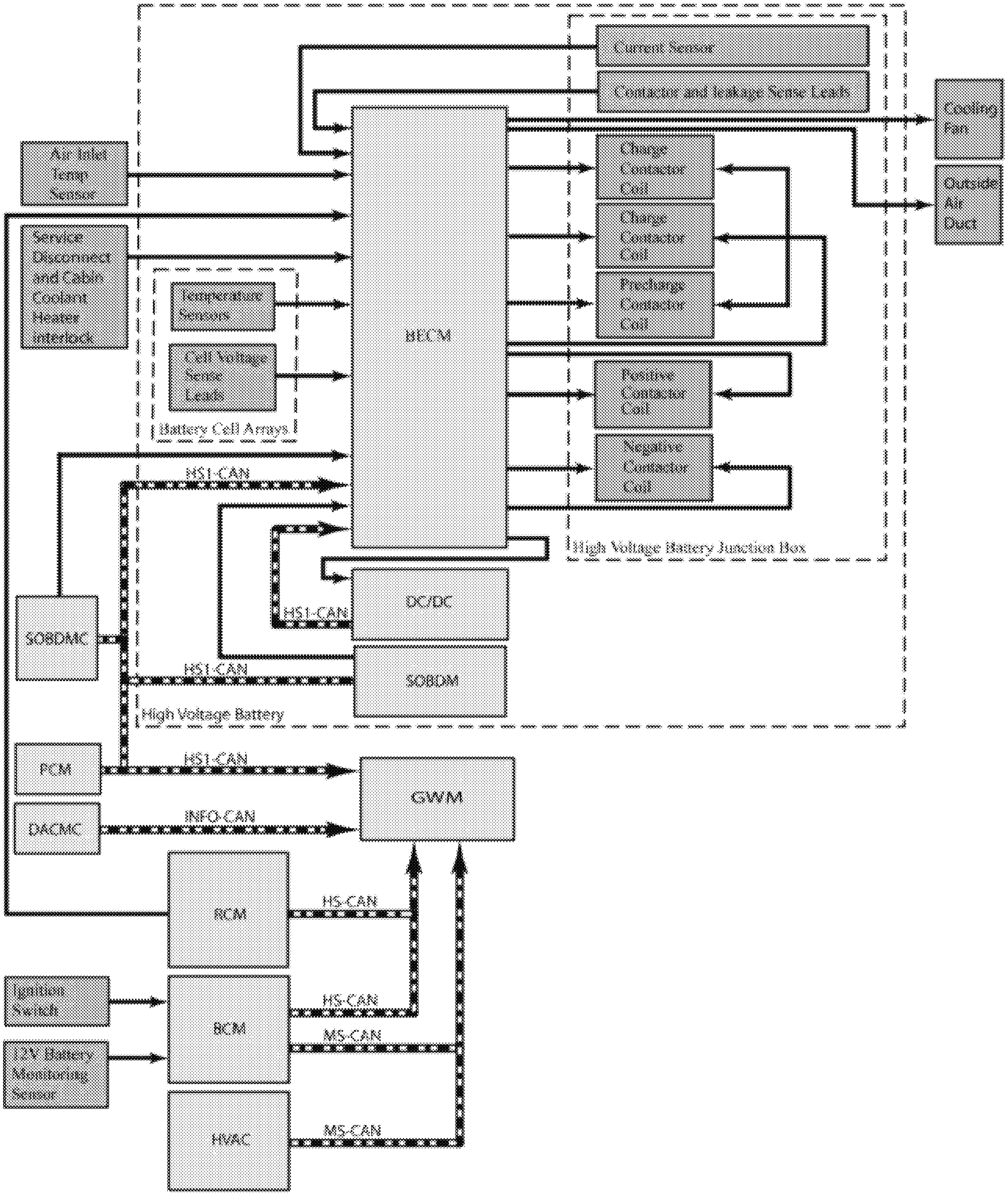
The vehicle can be placed in electric mode only (EV NOW) allowing only the electric motor to propel the vehicle. In this mode the high voltage battery depletes and the gas engine does not operate unless a calibratable condition exists such as a malfunction, heavy acceleration, high electric motor temperature, elevated high voltage battery temperature, low high voltage battery state of charge, or certain climate control functions are selected (e.g. defrost).

The high-voltage system utilizes approximately 300 volts DC, provided through high-voltage cables to its components and modules. The high-voltage cables and wiring are identified by orange harness tape or orange wire covering. All high-voltage components are marked with high-voltage warning labels with a high-voltage symbol.

The high voltage battery pack consists of the following components:

- High voltage battery service disconnect
- High voltage battery RH and LH cooling inlet ducts
- High voltage battery cooling fan and air outlet duct
- High voltage battery inlet air temperature sensor
- SOBDM/BCCM (Battery Charger Control Module)
- SOBDM outside air duct
- SOBDM cooling fan
- BECM (Battery Energy Control Module)
- DC/DC (Direct Current/Direct Current) converter control module
- High voltage battery junction box
- High voltage low current fuse (x3)
- High voltage high current fuse
- High voltage battery cell array cover (not serviceable)
- High voltage battery cell arrays (not serviceable)
- High voltage battery wiring harness (not serviceable)

The high voltage battery cell array cover, high voltage battery cell arrays, and high voltage battery wiring harness are serviced as part of the entire high voltage battery pack.


Current Sensor
Contactor and leakage Sense Leads
Cooling Fan
Outside Air Duct
Air Inlet Temp Sensor
Charge Contactor Coil
Charge Contactor Coil
Precharge Contactor Coil
Positive Contactor Coil
Negative Contactor Coil
Service Disconnect and Cabin Coolant Heater interlock
Temperature Sensors
Cell Voltage Sense Leads
Battery Cell Arrays
BECM
HS1-CAN
High Voltage Battery Junction Box
DC/DC
HS1-CAN
SOBDMC
HS1-CAN
SOBDM
High Voltage Battery
PCM
HS1-CAN
GWM
DACMC
INFO-CAN
RCM
HS-CAN
Ignition Switch
BCM
HS-CAN
MS-CAN
12V Battery Monitoring Sensor
HVAC
MS-CAN

E160358

| Battery Energy Control Module Performance Check Operation: | |
|---|---|
| DTCs | U0300 - Internal Control Module Software Incompatibility<br>U019B - Lost Communication With Battery Charger Control Module<br>U3012 - Control Module Improper Wake-up Performance<br>B11D5 - Restraints Event - Vehicle Disabled<br>P0AA6 - Hybrid/EV Battery Voltage System Isolation Fault |
| Monitor execution | |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1 sec |

| Battery Energy Control Module Performance malfunction thresholds: |
|---|
| U0300 - HW version and SW version not compatible<br>U019B - BCCM CAN message missing for 5 sec<br>U3012 - Power Sustain Relay Voltage <= 5.225 V or Contactor Open Request Not Received. Contactors are latched open due to LOW PSR but HPCM still requests contactors closed.<br>B11D5 - CAN signal from the Restraints Control Module indicates restraints event (crash) occurred.<br>P0AA6 - Leakage resistance < 195 kohm when charge contactors are closed. |

| Battery Pack Current Sensor Check Operation: | |
|---|---|
| DTCs | P0AC1 - Hybrid/EV Battery Pack Current Sensor "A" Circuit Low<br>P0AC2 - Hybrid/EV Battery Pack Current Sensor "A" Circuit High<br>P0AC0 - Hybrid/EV Battery Pack Current Sensor "A" Circuit Range/Performance<br>P0AC3 - Hybrid/EV Battery Pack Current Sensor "A" Circuit Intermittent/Erratic |
| Monitor execution | P0AC0: At a power up before contactors are closed<br>All others: continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1 sec |

| Battery Pack Current Sensor malfunction thresholds: |
|---|
| P0AC1 – Battery current <= 293.75 A<br>P0AC2 – Battery current => 293.75 A<br>P0AC0 – Battery current <= 3A or => 3A at power up before contactors are closed<br>P0AC3 – Battery current reference voltage > 5.5V or < 4.5 V |

| Battery Pack Sensor Check Operation: | |
|---|---|
| DTCs | P0AA7 - Hybrid/EV Battery Voltage Isolation Sensor Circuit<br>P1A3A - Hybrid/EV Battery Pack Voltage Sense System - Multiple Sensor Correlation<br>P1A39 - Hybrid/EV Battery Temperature Sensor System - Multiple Sensor Correlation |
| Monitor execution | |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1 sec |

| Battery Pack Sensor malfunction thresholds: |
|---|
| P0AA7 - The estimated pack voltage derived from the sum of the positive and negative leakage voltage is not <= 22.3982 v of the actual measured pack voltage<br>P1A3A - Pack voltage > 390 V, or < 1/2 of sum of cell voltages, and Half pack voltage < 35 V, or > 200V<br>P1A39 - 3 or more temperature sensor faults (there are 10 sensors total) > 95 deg C, or < -50 deg C, or<br>\| Any temp sensor - average of all temp sensors \| > 25 deg C." |

| Battery Pack Performance Check Operation: | |
|---|---|
| DTCs | P0B24 - Hybrid/EV Battery ""A"" Voltage Unstable<br>P0C30 - Hybrid/EV Battery Pack State of Charge High<br>P0AFB - Hybrid/EV Battery System Voltage High<br>P0B25 - Hybrid/EV Battery "A" Voltage Low<br>P0D37 - Hybrid/EV Battery System Current High<br>P0A7F - Hybrid/EV Battery Pack Deterioration |
| Monitor execution | |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 15 seconds |

| Battery Pack Performance malfunction thresholds: |
|---|
| P0B24 - Average cell voltage minus any cell voltage > 0.5 volts for 15 sec<br>P0C30 -<br>• State of charge => 100% when charge contactors are open (main contactors open or closed)<br>• Cell voltage > 4.5V when charge contactors are open (main contactors open or closed)<br>• State for charge => 101% when charge contactors are closed<br>• Cell voltage > 4.14 V when charge contactors are closed<br>P0AFB – Pack voltage > 362 V<br>P0B25 – State of change = 0% with main contactors open or closed<br>P0D37 – Battery current > 180 A for 200 sec, or > 250 A for 60 sec.<br>P0A7F – Battery pack power < 12 KW |

| Battery Pack Cell Balance Circuit Check Operation: | |
|---|---|
| DTCs | P0DAD - Hybrid/EV Battery Cell Balancing Circuit "A" Stuck On.<br>P0DB1 - Hybrid/EV Battery Cell Balancing Circuit "B" Stuck On.<br>P0DB5 - Hybrid/EV Battery Cell Balancing Circuit "C" Stuck On.<br>P0DB9 - Hybrid/EV Battery Cell Balancing Circuit "D" Stuck On.<br>P0DBD - Hybrid/EV Battery Cell Balancing Circuit "E" Stuck On.<br>P0DC1 - Hybrid/EV Battery Cell Balancing Circuit "F" Stuck On.<br>P0DC5 - Hybrid/EV Battery Cell Balancing Circuit "G" Stuck On.<br>P0DC9 - Hybrid/EV Battery Cell Balancing Circuit "H" Stuck On.<br>P0DCD - Hybrid/EV Battery Cell Balancing Circuit "I" Stuck On.<br>P0DD1 - Hybrid/EV Battery Cell Balancing Circuit "J" Stuck On.<br>P0DD5 - Hybrid/EV Battery Cell Balancing Circuit "K" Stuck On.<br>P0DD9 - Hybrid/EV Battery Cell Balancing Circuit "L" Stuck On.<br>P0DDD - Hybrid/EV Battery Cell Balancing Circuit "M" Stuck On.<br>P0DE1 - Hybrid/EV Battery Cell Balancing Circuit "N" Stuck On.<br>P0DAE - Hybrid/EV Battery Cell Balancing Circuit "A" Stuck Off.<br>P0DB2 - Hybrid/EV Battery Cell Balancing Circuit "B" Stuck Off.<br>P0DB6 - Hybrid/EV Battery Cell Balancing Circuit "C" Stuck Off.<br>P0DBA. Hybrid/EV Battery Cell Balancing Circuit "D" Stuck Off.<br>P0DBE. Hybrid/EV Battery Cell Balancing Circuit "E" Stuck Off.<br>P0DC2 - Hybrid/EV Battery Cell Balancing Circuit "F" Stuck Off.<br>P0DC6 - Hybrid/EV Battery Cell Balancing Circuit "G" Stuck Off.<br>P0DCA - Hybrid/EV Battery Cell Balancing Circuit "H" Stuck Off.<br>P0DCE. Hybrid/EV Battery Cell Balancing Circuit "I" Stuck Off.<br>P0DD2 - Hybrid/EV Battery Cell Balancing Circuit "J" Stuck Off.<br>P0DD6 - Hybrid/EV Battery Cell Balancing Circuit "K" Stuck Off.<br>P0DDA - Hybrid/EV Battery Cell Balancing Circuit "L" Stuck Off.<br>P0DDE - Hybrid/EV Battery Cell Balancing Circuit "M" Stuck Off.<br>P0DE2 - Hybrid/EV Battery Cell Balancing Circuit "N" Stuck Off. |
| Monitor execution | At a power up before contactors are closed, and two consecutive power cycles |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 100 msec |

| Battery Pack Cell Balance Circuit Check malfunction thresholds: |
|---|
| For the 6 cells monitored by each circuit: Any individual cell voltage differs from the average cell voltage by > 75 mV |

| Battery Pack Contactor Check Operation: | |
|---|---|
| DTCs | P0AA4 - Hybrid/EV Battery Negative Contactor Circuit Stuck Closed<br>P0AA5 - Hybrid/EV Battery Negative Contactor Circuit Stuck Open<br>P0AA2 - Hybrid/EV Battery Positive Contactor Circuit Stuck Open<br>P0B37 - High Voltage Service Disconnect Open |
| Monitor execution | |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1 sec |

| Battery Pack Contactor malfunction thresholds: |
|---|
| P0AA4 - Negative contactor status remains closed.<br>• Negative Contactor Measurement is > 90% Negative Half Pack voltage AND<br>• Negative Contactor Measurement is < 110% Negative Half Pack voltage AND<br>• Negative Contactor Measurement is > 30 volts.<br>P0AA5 - Negative contactor is commanded closed AND there is power to the contactor AND the contactor state is determined open.<br>Open is defined as NOT closed (i.e. mutually exclusive). Closed is defined above:<br>P0AA2 - Positive contactor is commanded closed AND there is power to the contactor AND the contactor state is determined open.<br>Open is defined as NOT closed (i.e. mutually exclusive). Closed is defined as:<br>• Negative Contactor Measurement is > 90% Negative Half Pack voltage AND<br>• Positive Contactor Measurement is < 110% Positive Half Pack voltage AND<br>• Positive Contactor Measurement is > 30 volts<br>P0B37 - The interlock and disconnect are mechanically interconnected such that removing the disconnect opens the interlock. Interlock status is reported open for the following criteria: PSR OR Charge wakeup is High, ACL latch is reported tripped by low level driver and interlock is reported open by low level driver. (ACL is anti-chatter latch). |

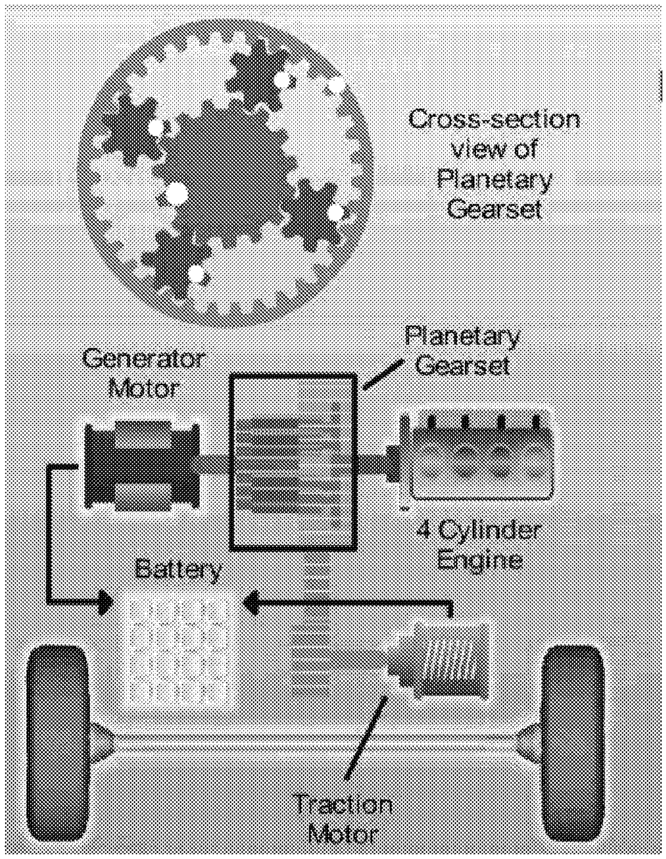
| Battery Pack Contactor Check Operation: | |
|---|---|
| DTCs | P0ADD - Hybrid/EV Battery Negative Contactor Control Circuit/Open<br>P0AE0 - Hybrid/EV Battery Negative Contactor Control Circuit High<br>P0AD9 - Hybrid/EV Battery Positive Contactor Control Circuit/Open<br>P0ADC - Hybrid/EV Battery Positive Contactor Control Circuit High<br>P0ADA - Hybrid/EV Battery Positive Contactor Control Circuit Range/Performance. |
| Monitor execution | |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1 sec |

| Battery Pack Contactor malfunction thresholds: |
|---|
| P0ADD - battery interlock is normal AND PSR or Charge Wakeup is High AND Negative Contactor state is open AND one of the following is TRUE when negative contactor is closed:<br>1.) completed the power up sequence and contactors are commanded closed but no power<br>2.) pre-charge is NOT yet complete and contactors are commanded closed but no power.<br>P0AE0 - Negative contactor low side driver in limited current mode.<br>P0AD9 - battery interlock is normal AND PSR or Charge Wakeup is High AND Positive Contactor state is open AND one of the following is TRUE when positive contactor is closed:<br>1.) completed the power up sequence and contactors are commanded closed but no power<br>2.) pre-charge is NOT yet complete and contactors are commanded closed but no power.<br>P0ADC - Positive contactor low side driver in limited current mode.<br>P0ADA – Positive contactor high side driver in over current mode. |

| Battery Pack Precharge Contactor Check Operation: | |
|---|---|
| DTCs | P0AE1 - Hybrid/EV Battery Precharge Contactor Circuit<br>P0AE7 - Hybrid/EV Battery Precharge Contactor Control Circuit High<br>P0AE5 - Hybrid/EV Battery Precharge Contactor Control Circuit Range/Performance |
| Monitor execution | |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1 sec |

| Battery Pack Precharge Contactor malfunction thresholds: |
|---|
| P0AE1 - Battery current < -10A or > -10A when precharge contactor is commanded closed<br>P0AE7 - Precharge contactor lowside driver in limited current mode<br>P0AE5 - \| Pack voltage - sum of contactor voltages \| > 20V when precharge contactor is commanded closed. |

## Transmission Control System Architecture




The primary function of the Powersplit transaxle is to manage torque between the electric motors, engine, and driveline. The planetary gear set provides series, parallel and split paths for power distribution from the battery and engine. The torque ratio between the series path and the parallel path is fixed by the geometry of the planetary gear set. The power split between the series path and the parallel path is determined by the relative speeds (all series if vehicle speed is zero and engine is on; all parallel if generator is stopped; split otherwise)

The system behavior is similar to a CVT with the effective gear ratio between the engine and the wheels is determined by the split.

The transaxle is controlled directly by the Hybrid Powertrain Control Module (HPCM). The HPCM communicates to the Engine Control Module (ECM), ABS Module, Battery Energy Control Module (BECM), and Body Control Module (BCM) using the high speed CAN communication link. The HPCM incorporates a standalone OBD-II system. The HPCM independently processes and stores fault codes, freeze frame, supports industry-standard PIDs as well as J1979 Mode 09 CALID and CVN. The HPCM does not directly illuminate the MIL, but requests the ECM to do so. The HPCM is located inside the Inverter System Controller (ISC) which also houses the motor and generator power electronics and the Variable Voltage Controller (VVC) hardware. It is not internally serviceable with the exception of reprogramming.

## Transmission Inputs

### Rotor Position Sensors

A Rotor position sensor (resolver) is located on both the electric Motor and Generator and is used to detect the angular position of the rotor. The analog waveform generated by the resolver is converted into a digital signal by the Resolver to Digital (R/D) converter. The digital signal is used to calculate speed and angular acceleration which is used to control the electric Motor and Generator. The speed information is also used to calculate vehicle speed and is broadcasted to other modules over CAN. If a resolver hardware or wiring fault is detected, or a failure with the R/D converter is detected, a P0A90-xx fault for the motor or a P0A92-xx fault for the generator will be stored. If the resolver was not properly configured (initialized) by the assembly plant or if the ISC is replaced, a P0A3F-55 will be stored for the motor, or P0A4B-55 will be stored for the generator.

### Temperature Sensors

The Transmission Fluid Temperature Sensor (TFT) is monitored for open and short circuit faults and for in-range faults (P0710-xx) where Trans Fluid, Motor Coil and Generator Coil temperatures do not correlate properly.

The Motor and Generator Coil Temperature Sensors are monitored for open and short circuit faults and for in-range faults where Trans Fluid, Motor Coil and Generator Coil temperatures do not correlate properly. P0A2A-xx and P0A2B-xx are related to Motor Coil Sensor failure, P0A36-xx and P0A37-xx are related to Generator Coil Sensor failure. The Motor and Generator coils are also monitored for over-temperature (P0A2F-94).

The Motor and Generator Inverter Temperature Sensors are monitored for open and short circuit faults. P0A78-11 and P0A78-13 are related to Motor Inverter Sensor failure, P0A7A-11 and P0A78-13 are related to Generator Inverter Sensor failure. The Motor and Generator Inverters are also monitored for over-temperature (P0A3C-94).

## HPCM Outputs

### Inverter Control

Upon receiving the wheel torque demanded by the driver from the ECM over CAN communication, the HPCM calculates the required torque of the electric Motor and Generator to meet driver demand. The HPCM will then control the inverter over U, V, and W phase gate signals to regulate DC current into AC current that is fed into the stator.

The Motor and Generator gate signal lines are monitored for open circuits. A P0A78-1C and P0A78-11 faults are for the Motor and a P0A7A-1C and P0A78-11 are for the Generator. The inverter is also monitored for various faults such as over current, current sensor fault, current regulation fault, temperature sensor fault, etc. and will store a P0A78 fault for the Motor and a P0A7A fault for the Generator upon detection of a malfunction.

## Hybrid Powertrain Control Module (HPCM)

The HPCM monitors itself by using various software monitoring functions. The flash ROM is checked using a checksum calculation, and will set P0605-00 if ROM errors are detected. The EEPROM is emulated in the flash ROM.

The Motor/Generator Control Unit (MGCU) use similar types of RAM/ROM tests. If a fault is detected, a the MGCU will request to store P0A1B-06, P0A1B-49, P060C-41, or P060C-43 and these will be reported by the HPCM.

### CAN Communications error

The HPCM receives information from the ECM (and various other modules) via CAN. If the CAN link fails, the HPCM no longer has torque or engine speed information available. The HPCM will store a U0100-00 fault code if it doesn't receive any more CAN messages from the ECM.

The HPCM receives wheel speed and brake torque request information from the Antilock Brake System (ABS) module. The HPCM will store U0121-00 fault code if communication with the ABS module is lost. The HPCM also receives information from the Battery Energy Control Module (BECM) and a U0111-00 fault will be stored if the communication with the BECM is lost.

## Hybrid Powertrain Control Module (HPCM) External Inputs

The HPCM monitors several hardwired inputs from the following sources:

**High Voltage (HV) Interlock (HVIL)** is a switched input that monitors access to the HV DC connectors. If opened, it will cause the HV circuit to be de-energized and the vehicle will be shut down.

**Clean Tach Out (CTO)** is a signal from the ECM, which is used to determine Engine Speed.

**Electric Motor Position Sensors** are used to measure the angular position of the rotor for the motor and generator.

**Electric Drive Temperature Sensors** are used to monitor hardware component temperatures that are critical to the electric drive system.

**Electric Vehicle (EV) Mode** is a driver-selectable switched input that determines the driver's request for one of the special EV driving modes (PHEV only).

## High Voltage Interlock

The HV Interlock (HVIL) monitors access to the high voltage DC connectors. When the cover for the high voltage DC connectors at the ISC is removed, the HVIL circuit is opened, thus causing the HPCM to request the HV contactors to be opened and the vehicle to shutdown.

| High Voltage Interlock Open Check Operation: | |
|---|---|
| DTCs | P0A0A (High Voltage System Interlock Circuit) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 100 msec |

| High Voltage Interlock Open check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 8.0 V | - |
| Vehicle Speed | - | < 2 kph |

| High Voltage Interlock Open check malfunction thresholds: |
|---|
| HVIL input circuit is OPEN (0 v). |

## CTO (Clean Tach Out)

The CTO signal is sent from the ECM to the HPCM. The signal is sent at 10 degrees before Top Dead Center (TDC) for each cylinder. Thus, for a 4 cylinder engine, this translates into the HPCM seeing this signal every 180 degrees of engine rotation. This signal is used to calculate Engine Speed and engine rotational position.

| **CTO Signal Check Operation:** | |
|---|---|
| DTCs | P0726 (Engine Speed Input Circuit Range/Performance Signal Compare Failure) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 2000 msec |

| **CTO Input Circuit Failure and Out- of- Range check entry conditions:** | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0 V | 19.0 V |
| Engine Speed | 50 rad/s | 200 rad/s |

| **CTO Input Circuit Out-of-Range check malfunction thresholds:** |
|---|
| \| ECM Engine Speed (CAN signal) – ECM Engine Speed (based on CTO) \| > 50 rad/s for more than 200 msec |

## Electric Motor Position Sensors

These are used to measure the angular position of the rotor for the motor and generator. They are used by low-level machine control algorithms to calculate current angle. Also, they are used by higher-level control strategies to determine motor and generator rotational speeds and accelerations.

| Motor/Gen Rotor Position Check Operation: | |
|---|---|
| DTCs | P0C17 (Drive Motor Position Sensor Not Learned)<br>P0C50 (Drive Motor "A" Position Sensor Circuit "A")<br>P0A44 (Drive Motor Position Sensor Circuit Overspeed)<br>P0DFC (Generator Position Sensor Circuit Not Learned)<br>P0A50 (Generator Position Sensor Circuit)<br>P0A78 (Drive Motor Inverter Performance -- Circuit Voltage Out of Range)<br>P0A7A (Generator Inverter Performance -- Circuit Voltage Out of Range)<br>P0C50 (Drive Motor "A" Position Sensor Circuit "A")<br>P0A90 (Drive Motor Performance)<br>P0A40 (Drive Motor "A" Position Sensor Circuit Range/Performance)<br>P0C64 (Generator Position Sensor Circuit "A")<br>P0A92 (Hybrid Generator Performance)<br>P0A4C (Generator Position Sensor Circuit Range/Performance) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | |

| Motor/Gen Rotor Position Circuit Voltage Out-of-Range check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 50 msec | none |
| 12V Battery voltage | 6.0 V | 19.0 V |
| Internal Communication Fault Check | PASS | |
| Gate Drive Circuit Fault Check | PASS | |

| Motor/Gen Rotor Position Circuit Overspeed entry conditions:<br>Motor/Gen Performance General Signal Failure entry conditions:<br>Motor/Gen Rotor Position Sensor Not Configured entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 700 msec | none |
| 12V Battery voltage | 6.0 V | 19.0 V |
| Internal Communication Fault Check | PASS | |

| Motor/Gen Performance Circuit Voltage Below Threshold entry conditions | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 50 msec | none |
| 12V Battery voltage | 6.0 V | 19.0 V |

| | | |
|---|---|---|
| Internal Communication Fault Check | PASS | |
| Internal Reference Voltages Fault Check | PASS | |
| Gate Drive Circuit Fault Check | PASS | |

| Motor/Gen Performance Invalid Serial Data entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 50 msec | none |
| 12V Battery voltage | 6.0 V | 19.0 V |
| Internal Communication Fault Check | PASS | |
| Mot/Gen Speed | > 0 RPM | |
| Mot/Gen Inverter Over Current Fault | FAIL | |

| Motor/Gen Rotor Position Sensor Not Configured malfunction thresholds: |
|---|
| Motor/Generator Resolver Position (stored in EEPROM) is not in acceptable range. |

| Motor/Gen Rotor Position Circuit Overspeed malfunction thresholds: |
|---|
| ( Motor measured speed is greater than 1596 for greater than 10 msec OR<br>Motor measured speed is greater than 1544 for greater than 100 msec. )<br>( Generator measured speed is greater than 1596 for greater than 10 msec OR<br>Generator measured speed is greater than 1544 for greater than 100 msec. ) |

| Motor/Gen Rotor Position Circuit Voltage Out-of-Range malfunction thresholds: |
|---|
| Motor/Generator Gate Drive Power Supply > 15.08 V OR<br>Motor/Generator Resolver Power Supply less than 4.7 V OR greater than 5.3 V |

| Motor/Gen Drive Motor Performance General Signal Failure malfunction thresholds: |
|---|
| Motor/Generator Resolver hardwired fault line indicates faulted high-> 10ms if RUNNING. OR > 600ms at powerup OR<br>Motor/Generator Resolver hardwired fault line intermittent |

| Motor/Gen Performance Circuit Voltage Below Threshold malfunction thresholds: |
|---|
| Motor/Generator Resolver circuit power supply less than 15.6 V OR greater than 21.5 V |

| Motor/Gen Performance Invalid Serial Data malfunction thresholds: |
|---|
| Motor/Generator Resolver ABZ data differs from serial data by more than 3.6 deg for more than 20 msec. |

| Motor/Gen Performance |
|---|
| 35A difference between command and feedback for 500ms continuously. |

## Electric Motor HV Current Sensors

These are used by the MGCU (Motor/Generator Control Unit) to measure the AC current for each phase of the motor and generator. They are used by low-level machine control algorithms to calculate current magnitude and angle. Also, they are used by to insure correct connection of the AC 3-phase circuits to the motor and generator.

| Motor/Gen Current Sensor Check Operation: | |
|---|---|
| DTCs | P0A78 (Drive Motor Inverter Performance - Current Above Threshold)<br>P0A7A (Generator Inverter Performance - Current Above Threshold)<br>P0C00 Drive Motor "A" Current Low)<br>P0C03 (Drive Motor "B" Current Low)<br>P1A16 (Variable Voltage Controller Voltage Control Circuit - Current Above Threshold)<br>P0D2D (Drive Motor "A" Inverter Voltage Sensor Circuit) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | |

| Motor/Gen Inverter Performance Current Above Threshold entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 50 msec | none |
| 12V Battery voltage | 6.0 V | 19.0 V |
| Internal Reference Voltages Fault Check | PASS | |
| Internal Inverter Fault Check | PASS | |

| Motor/Gen Inverter Performance Current Out-Of Range entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 50 msec | none |
| 12V Battery voltage | 6.0 V | 19.0 V |
| Internal Reference Voltages Fault Check | PASS | |
| Mot/Gen Operating Mode | Any mode except Terminate | |

| Variable Voltage Controller Control Circuit Current Above Threshold entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 50 msec | none |
| 12V Battery voltage | 6.0 V | 19.0 V |
| Internal Reference Voltages Fault Check | PASS | |
| VVC Operating Mode | Boost Mode | |

| Motor/Gen Inverter Performance Current Above Threshold malfunction thresholds: |
|---|
| Motor/Gen current sensor over current declared by MGCU:<br>Motor current magnitude > 600A for 400us OR > 30 A for 200ms at power up<br>Generator current magnitude > 300A for 400us OR > 15 A for 200ms at powerup |

| Motor/Gen Inverter Performance Current Out-Of Range malfunction thresholds: |
|---|
| Motor/Gen phase circuit fault declared by MGCU - < 5 A for duration of test (100ms) at power up |

| Variable Voltage Controller Control Circuit Current Above Threshold malfunction thresholds: |
|---|
| Variable Voltage Controller current measured greater than 300 amps. |

| Inverter DC Voltage Sensor Circuit malfunction thresholds: |
|---|
| < 0.235V for 100ms at power up |

## Electric Drive Temperature Inputs

**Motor/Generator Coil Temperature Sensors**
These temperature sensors are located on the coil windings of the stators of the motor and the generator.

| Motor/Generator Coil Temperature Sensor check Operation: | |
|---|---|
| DTCs | P0A2C (Drive Motor "A" Temperature Sensor Circuit Low)<br>P0A2D (Drive Motor "A" Temperature Sensor Circuit High)<br>P0A2B (Drive Motor "A" Temperature Sensor Circuit Range/Performance)<br>P0A2F (Drive Motor "A" Over Temperature -- Unexpected Operation)<br>P0A38 (Generator Temperature Sensor Circuit Low)<br>P0A39 (Generator Temperature Sensor Circuit High)<br>P0A37 (Generator Temperature Sensor Circuit Range/Performance) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 200 msec |

| Motor/Generator Coil Temp Circuit Short/Open check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 2 seconds | none |
| 12V Battery voltage | 6.0 V | 19.0 V |
| Internal Reference Voltages Fault Check | PASS | |

| Motor/Generator Coil Temp Over Temp check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0V | 19.0 V |
| Sensors OK | Motor Temp Sensor = OK<br>Generator Temp Sensor = OK<br>Oil Temp Sensor = OK | |
| Internal Reference Voltages Fault Check | PASS | |

| Motor/Generator Coil Temp In-Range/Performance entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 2 seconds | 10 seconds |
| 12V Battery voltage | 6.0V | 19.0 V |
| Sensors OK | Motor Temp Sensor = OK<br>Generator Temp Sensor = OK<br>Oil Temp Sensor = OK | |
| Internal Reference Voltages Fault Check | PASS | |
| Key-off timer | 200 minutes | |

| Motor/Generator Coil Temp Sensor Low check malfunction thresholds: |
|---|
| Motor/Generator Coil Temp input voltage < 0.1 V for more than 32 msec |

| Motor/Generator Coil Temp Sensor High check malfunction thresholds: |
|---|
| Motor/Generator Coil Temp input voltage > 4.8 V for more than 32 msec |

| Motor/Generator Coil Temp Sensor Range/Performance check malfunction thresholds: |
|---|
| **Motor Coil Temp (P0A2B)**<br>\| Transmission Fluid Temperature - Generator Coil Temp \| < 10 deg C AND<br>\| Transmission Fluid Temperature - Motor Coil Temp \| > 30 deg C AND<br>\| Motor Coil Temp - Generator Coil Temp \| > 30 deg C<br><br>**Generator Coil Temp (P0A37)**<br>\| Transmission Fluid Temperature - Generator Coil Temp \| > 30 deg C AND<br>\| Transmission Fluid Temperature - Motor Coil Temp \| < 10 deg C AND<br>\| Motor Coil Temp - Generator Coil Temp \| > 30 deg C |

| Motor/Generator Coil Temp Over Temp check malfunction thresholds: |
|---|
| **Motor/Generator Coil Temp over Temp**<br><br>Motor/Generator Coil Temp > 140 deg C OR Transmission Oil Temp > 115 deg C |

### Transmission Fluid (Oil) Temperature Sensor

The Transmission Fluid Temperature sensor measures the temperature of the transmission fluid.

| Trans Fluid Temperature check Operation: | |
|---|---|
| DTCs | P0713 (Transmission Fluid Temp Sensor Circuit High)<br>P0712 (Transmission Fluid Temp Sensor Circuit Low)<br>P0711 (Transmission Fluid Temp Sensor Circuit Range/Performance |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 200 msec |

| Trans Fluid Temp Circuit Low/High check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 0.5 seconds | |
| 12V Battery voltage | 6.0V | 19.0 V |
| Internal Reference Voltages Fault Check | PASS | |

| Trans Fluid Temp Signal Range/Performance entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 2 seconds | 30 seconds |
| 12V Battery voltage | 6.0V | 19.0 V |
| Internal Reference Voltages Fault Check | PASS | |
| Sensors OK | Motor Temp Sensor = OK<br>Generator Temp Sensor = OK<br>Oil Temp Sensor = OK | |
| Key-off timer | 200 minutes | |

| Trans Fluid Temp Sensor Circuit High malfunction thresholds: |
|---|
| Transmission Fluid Temp input voltage < 0.1 V for more than 32 msec |

| Trans Fluid Temp Sensor Circuit Low malfunction thresholds: |
|---|
| Motor Coil Temperature > 10 deg C AND<br>Generator Coil Temperature > 10 deg C AND<br>Transmission Fluid Temp input voltage > 4.86 V for more than 32 msec |

| Trans Fluid Temp Sensor Range/Performance failure check malfunction thresholds: |
|---|
| \| Transmission Fluid Temperature - Generator Coil Temp \| > 30 deg C AND<br>\| Transmission Fluid Temperature - Motor Coil Temp \| > 30 deg C AND<br>\| Motor Coil Temp - Generator Coil Temp \| < 10 deg C |

### Motor/Generator Inverter Temperature Sensors

These temperature sensors are located on the Motor and Generator Inverters.

| Motor/Generator Inverter Temperature Check Operation: | |
|---|---|
| DTCs | P0AEF (Drive Motor Inverter Temperature Sensor "A" Circuit Low)<br>P0AF0 (Drive Motor Inverter Temperature Sensor "A" Circuit High)<br>P0AEE (Drive Motor Inverter Temperature Sensor "A" Circuit Range/Performance)<br>P0A3C (Drive Motor "A" Inverter Over Temperature)<br>P0BCE (Generator Inverter Temperature Sensor "A" Circuit Low)<br>P0CF (Generator Inverter Temperature Sensor "A" Circuit High)<br>P0BCD (Generator Inverter Temperature Sensor "A" Circuit Range/Performance) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | Continuous |

| Motor/Generator Inverter Temp Sensor Circuit Short/Open check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0V | 19.0 V |
| Internal Reference Voltages Fault Check | PASS | |

| Motor/Generator Inverter Temp Sensor Circuit Short/Open check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0V | 19.0 V |
| Internal Reference Voltages Fault Check | PASS | |
| Sensors OK | Motor Inverter Temp sensor = OK<br>Generator Inverter Temp sensor = OK<br>VVC IGBT Temp Sensor = OK<br>VVC Inductor Temp Sensor = OK | |

| Motor/Generator Inverter Temp Sensor Short check malfunction thresholds: |
|---|
| Motor Inverter Temp input voltage < 0.78 V |

| Motor/Generator Inverter Temp Sensor Open check malfunction thresholds: |
|---|
| Motor Inverter Temp input voltage > 4.56 V |

| Motor/Generator Inverter Temp Over Temp check malfunction thresholds: |
|---|
| Voltage Boost Converter (VVC) IGBT temperature > 139 deg C OR<br>Voltage Boost Converter (VVC) Inductor temperature > 159 deg C OR<br>Generator Inverter IGBT temperature > 123 deg C OR<br>Motor Inverter IGBT temperature > 123 deg C |

| Motor/Generator Temp Sensor Range/Performance failure check malfunction thresholds: |
|---|
| \| Motor Temperature – Engine Coolant Temp \| > 30 deg C AND<br>Engin Off Soak Time > 210 min |

**High Voltage DC/DC Converter**

| Inverter High Voltage Sensor Check Operation: | |
|---|---|
| DTCs | P1A07 - Inverter High Voltage Performance<br>P0C79 - Drive Motor "A" Inverter Voltage Too High<br>P0DA8 - Hybrid/EV Battery Voltage/Drive Motor "A" Inverter Voltage Correlation |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | U0111, P0D2D |
| Monitoring Duration | Continuous |

| Inverter High Voltage Sensor check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0V | 19.0 V |

| Inverter High Voltage Sensor check malfunction thresholds: |
|---|
| P1A07 - Battery voltage CAN signal < 150V for 100ms OR measured input voltage signal voltage < 150V for 100ms<br>P0C79 - DC bus voltage measurement voltage > 516V for 10ms.<br>P0DA8 - Difference between High Voltage Battery voltage sensor and inverter input voltage sensor > 60V OR difference between input/output inverter voltage sensors > 60V. |

| Inverter DC/DC Converter Check Operation: | |
|---|---|
| DTCs | P1A16 - Variable Voltage Controller Voltage Control Circuit<br>P1A17 - Variable Voltage Controller Processor<br>P0A94 - DC/DC Converter Performance |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | P0560, P0562, U0111, P1A07 |
| Monitoring Duration | Continuous |

| Inverter DC/DC Converter check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0V | 19.0 V |

| Inverter DC/DC Converter check malfunction thresholds: |
|---|
| P1A16:<br>Input voltage sensor reading below < 0.235V for 10 msec. OR<br>Current sensor reading > 300 Amps for 1 sec. OR<br>Motor/generator torque de-rate for voltage protection > 50% for 1 sec. OR<br>Voltage difference across Variable Voltage Converter > 30 V for 100 msec. during self-test OR<br>Variable Voltage Controller upper switch hardware failure for >200 usec.<br>P1A17:<br>Variable Voltage Controller Gate Drive power supply > 15.3V, < 0.1V OR<br>Variable Voltage Controller upper switch temperature sensor fault > 4.55V , < 0.779V OR<br>Variable Voltage Controller lower switch temperature sensor fault > 4.55V , < 0.779V OR<br>Variable Voltage Controller lower switch hardware failure for >200 usec<br>Variable Voltage Controller inductor current sensor offset > 15A at power-up<br>Variable Voltage Controller inductor current sensor voltage < 4.5V or > 6.0V<br>P0A94:<br>Calculated Inductor current is > 50 A different from measured current in controlled operating conditions for > 4 sec. |

| Inverter Inductor Temperature Sensor Check Operation: | |
|---|---|
| DTCs | P1A18 - Variable Voltage Controller Inductor Temperature Sensor Circuit<br>P1A19 - Variable Voltage Controller Driver Temperature Sensor Circuit |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | P0560, P2610 |
| Monitoring Duration | Continuous |

| Inverter Inductor Temperature Sensor check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0V | 19.0 V |

| Inverter Inductor Temperature Sensor check malfunction thresholds: |
|---|
| P1A18:<br>Inductor temperature sensor voltage < 0.067V, > 4.86V OR<br>Inductor Overtemperature conditions > 165 deg C for 1 sec OR<br>Inductor temperature differs from ECT > 30 deg C after a 180 min engine off soak time.<br>P1A19:<br>Power Electronics temperature differs from ECT > 30 deg C after a 180 min engine off soak time. |

## EV Mode Input Switch (PHEV only)

Electric Vehicle (EV) Mode is driver-selectable switched input that determines the driver's request for one of the three EV driving modes: ***Auto*** – this is normal PHEV operation (charge depleting) which attempts to minimize use of internal combustion engine operation until PHEV battery is mostly depleted then reverts to conventional hybrid (charge sustaining) operation, ***EV Now*** – this mode forces the internal combustion engine off under all non-faulted driving conditions, and ***EV Later*** – this mode forces the vehicle into conventional hybrid (charge sustaining) to allow a reserve of battery energy to be used later once driver selects Auto mode again.

| **EV (transmission) Mode Check Operation:** | |
|---|---|
| DTCs | P071A (Transmission Mode Switch "A" Circuit -- intermittent)<br>P071B (Transmission Mode Switch "A" Circuit Low) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | Continuous |

| **EV (transmission) Mode Check Circuit check entry conditions:** | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0V | 19.0 V |

| **EV (transmission) Mode Check Circuit intermittent check malfunction thresholds:** |
|---|
| EV Switch transitions low to high more than 10 times in 300 msec. |

| **EV (transmission) Mode Check Circuit Low malfunction thresholds:** |
|---|
| EV Switch input remains low for more than 30 seconds. |

## Transmission Range Sensor Inputs

| Transmission Range Sensor Check Operation: | |
|---|---|
| DTCs | P2800 – Transmission Range Sensor B Circuit (PRNDL input)<br>P2806 – Transmission Range Sensor Alignment |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| Transmission range sensor check malfunction thresholds: | | | | | |
|---|---|---|---|---|---|
| TR Sensor | Park | Reverse | Neutral | Drive | Low |
| TR_A1 (VOLTS | 3.84 - 4.77 | 2.58 - 3.31 | 1.82 - 2.56 | 0.97 - 1.79 | 0.20 - 0.92 |
| TR_A2 (VOLTS | 0.20 - 1.08 | 1.56 - 2.25 | 2.26 - 2.96 | 2.97 - 3.74 | 3.77 - 4.45 |

| Transmission range sensor check malfunction thresholds: |
|---|
| P20800: INVALID gear position signal received over CAN from ECM. |
| P2806: Mechanical Parking Pawl failure. Motor rotates > 9 radians when parking pawl is expected to be engaged in transaxle. |

## Transmission Auxiliary Oil Pump

| Transmission Auxiliary Oil Pump Check Operation: | |
|---|---|
| DTCs | P175A - Transmission Fluid Over Temperature Condition - Electric Transmission Fluid Pump Disabled<br>P0B0D - Electric/Auxiliary Transmission Fluid Pump Motor Control Module<br>P0C27 - Electric/Auxiliary Transmission Fluid Pump "A" Motor Current Low<br>P0C28 - Electric/Auxiliary Transmission Fluid Pump "A" Motor Current High<br>P0C29 - Electric/Auxiliary Transmission Fluid Pump "A" Driver Circuit Performance<br>P0C2A - Electric/Auxiliary Transmission Fluid Pump "A" Motor Stalled<br>P0C2C - Electric Transmission Fluid Pump Control Module Feedback Signal Range/Performance<br>P0C2D - Electric Transmission Fluid Pump Control Module Feedback Signal Low<br>P0C2E - Electric Transmission Fluid Pump Control Module Feedback Signal High<br>P2796 - Electric Transmission Fluid Pump Control Circuit |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| Transmission Auxiliary Oil Pump check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Ambient Temperature | 10 deg C | |
| 12V Battery voltage | 6.0V | 19.0 V |

| Transmission Auxiliary Oil Pump check malfunction thresholds: |
|---|
| P175A: TAOP circuit board temperature > 130 deg C for 3 sec. |
| P0B0D: TAOP speed is > 105% or < 95% of commanded speed for 3 sec |
| P0C27: TAOP current is < 0.5 Amps at 1000rpm to <1.2 Amps at 4000rpm. For 3 sec |
| P0C28: TAOP current is > 12.5 Amps for 3 sec |
| P0C29: TAOP current and speed meet conditions for P0B0D and either P0C27 or P0C28 for 3 sec. |
| P0C2A: Pump speed =0 when commanded non-zero for 3 sec, OR circuit board temp > 135 deg C OR Over-current > 12.5 Amps for > 20 sec. OR Pump supplied voltage < 6.0 Volts or > 18.0 Volts for 325 ms. |
| P0C2C: Duty cycle of PWM signal measured by TAOP outside the 10 defined zones of operation > 3.0 sec. |
| P0C2D: Duty cycle of PWM signal measured from TAOP is < 9 % duty cycle for 3 seconds. |
| P0C2E: Duty cycle of PWM signal measured from TAOP is > 91 % duty cycle for 3 seconds. |
| P2796: PWM speed command signal on the separate control circuit < 80 Hz or > 120 Hz for 3 sec. |

## Motor Electronics Coolant Pump Control Circuit

| Motor Electronics Coolant Pump Control Circuit Check Operation: | |
|---|---|
| DTCs | P0A06 (Motor Electronics Coolant Pump (MECP) Control Circuit Low)<br>P0A07 (Motor Electronics Coolant Pump (MECP) Control Circuit High)<br>P0C73 (Motor Electronics Coolant Pump "A" Control Performance) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 5 sec |

| Motor Electronics Coolant Pump Control Circuit check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0V | 19.0 V |

| Motor Electronics Coolant Pump Control Circuit check malfunction thresholds: |
|---|
| P0A06 – MECP output driver faulted for > 5 sec<br>P0A07 - MECP output driver faulted (overcurrent) for > 0.25 sec<br>P0C73 – No communication received from pump > 9.25 sec OR communication received from pump that a confirmed fault exists > 1.25 sec OR communication received from pump outside of expected frequency/duty cycle > 1 sec. |

## General System Voltage Checks

| General System Voltage Check Operation: | |
|---|---|
| DTCs | P0560 – System Voltage<br>P0562 – System Voltage Low<br>P0563 – System Voltage High<br>P0A23 – Generator Torque Sensor Circuit Range/Performance<br>P0A18 – Motor Torque Sensor Circuit Range/Performance<br>P1633 - Keep Alive Power Voltage Too Low |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1 sec |

| General System Voltage Check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Time after vehicle power up | 500 msec | none |
| 12V Battery voltage | 6.0V | 19.0 V |

**General System Voltage check malfunction thresholds:**

P0560:

- 5V power supply out of range (4.75V > x) OR (x > 5.25V)
- 3.3V power supply out of range (3.46V < x) OR (x < 3.13V)
- 1.5 V power supply out of range (1.57V < x) OR (x < 1.42V)

P0562:

- Battery voltage when vehicle is running and in a torque producing state < 8.2V
- KAPWR voltage out of range (x > 19.0V) OR (x < 5.95V)

P0563:

- Battery voltage too high> 19.0V

P0A23:

- Generator sensor reference voltage out of range > 6V or < 4.50V for 500ms.

P0A18:

- Motor current sensor reference voltage out of range > 6V or < 4.50V for 500ms.

P1633

- Voltage below 6.0V for 20 seconds, or 5 seconds during module self-test.

## Internal ECU Checks

| Internal ECU Check Operation: | |
|---|---|
| DTCs | P0600 – Serial Communication Link<br>P0603 - Internal Control Module Keep Alive Memory (KAM) Error<br>P0604 - Internal Control Module Random Access Memory (RAM) Error<br>P0605 - Internal Control Module Read Only Memory (ROM) Error<br>P0607 - Internal Control Module Read Only Memory (ROM) Error<br>P060A – Internal Control Module Monitoring Processor<br>P060B - Internal Control Module A/D Processing Performance<br>P060C - Internal Control Module Main Processor Performance<br>P0613 – TCM Processor<br>P061A - Internal Control Module Torque Performance<br>P06B8 - Internal Control Module Non-Volatile Random Access Memory (NVRAM) Error<br>P0A1D - Hybrid/EV Powertrain Control Module "A"<br>P1A08 - Generator Mode Signal |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 1 sec |

| Internal ECU Check malfunction thresholds: |
|---|
| P0600 – SPI message fault (checksum/header/timing/frame) |
| P0603 – KAM checksum error |
| P0604 – RAM checksum error |
| P0605 – ROM checksum error |
| P0607 - Error detected in CPU instruction test |
| P060A – Error detected in Motor Control Unit (RAM/ROM/Communications/Safety Monitor) |
| P060B – A/D redundant check error compared with main software A/D |
| P060C – CAN network data errors (torque/motor speed/pedal/gear/torque) |
| P0613 – Processor resets, micro software mismatch, torque validity |
| P061A – Excess torque detected |
| P06B8 – NVRAM read/write failure |
| P0A1D - Inter-processor Serial Communication failure |
| P1A08 - Generator mode command invalid for Neutral Gear operation when vehicle speed < 2 kph and gear position is NEUTRAL for < 1 sec. |

## General Hybrid System

| General System Check Operation: | |
|---|---|
| DTCs | P0A1A - Generator Control Module<br>P0A1B - Drive Motor "A" Control Module<br>P1920 – Engine Speed Signal<br>P1A13 - Hybrid Powertrain Control Module - Regenerative Braking Disabled<br>P1A1B - Brake System Control Module - Forced Engine Running<br>U0100 - Lost Communication With ECM / PCM "A"<br>U0121 - Lost Communication With Anti-Lock Brake System (ABS) Control Module<br>U0164 - Lost Communication With HVAC Control Module<br>U0300 - Internal Control Module Software Incompatibility<br>U0401 - Invalid Data Received from ECM/PCM "A"<br>U0412 - Invalid Data Received from Battery Energy Control Module "A"<br>U0418 - Invalid Data Received from Brake System Control Module "A" |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | P0A23, P0A92, P0A7A, P0C64 for P0A1A<br>P1A18, P0A90, P0A78,P0C50 for P1A1B |
| Monitoring Duration | Continuous |

| General System Check malfunction thresholds: |
|---|
| P0A1A - Generator Torque estimate error, difference between Generator torque estimate and command > 40Nm for 550 ms or Total Torque estimate error, difference between Total torque command and Total torque > 800Nm more than demand for > 500ms. |
| P0A1B - Motor Torque Estimate Error, Difference between Motor torque estimate and command > 60Nm for 550 ms or Total Torque estimate error, Difference between Total torque command and Total torque estimate > 800Nm more than demand for > 500ms. |
| P1920 - Difference between engine speed CAN signal and internal engine speed calculation > 500 rpm for 500 ms OR > 550rpm for 1000 ms. |
| P1A13 - Regenerative Braking Disabled by request of Brake System Control Module due to regenerative braking system fault. |
| P1A1B – Forced Engine Running by request of Brake System Control Module due to regenerative braking system fault. |
| U0100 – Lost Communication with PCM > 1 sec. |
| U0121 – Lost Communication with ABS module > 1 sec. |
| U0164 - Lost Communication with HVAC module > 1 sec. |
| U0300 - Internal HPCM monitor software version mismatch. |
| U0401 - Invalid Data Received from ECM/PCM "A" |
| U0412 - Invalid Data Received from Battery Energy Control Module "A" |
| U0418 - Invalid Data Received from Brake System Control Module "A" |

## PCM On Board Diagnostic Executive

The On-Board Diagnostic (OBD) Executive is a portion of the PCM strategy that manages the diagnostic trouble codes and operating modes for all diagnostic tests. It is the "traffic cop" of the diagnostic system. The Diagnostic Executive performs the following functions:

- Sequence the OBD monitors such that when a test runs, each input that it relies upon has already been tested. For 2008 MY and beyond ISO 14229 programs, the OBD monitors are no longer sequenced by the diagnostic executive.
- Controls and co-ordinates the execution of the individual OBD system monitors: Catalyst, Misfire, EGR, O2, Fuel, AIR, EVAP and, Comprehensive Component Monitor (CCM). For 2008 MY and beyond ISO 14229 programs, the execution of the OBD monitors is no longer controlled and coordinated by the diagnostic executive.
- Stores freeze frame and "similar condition" data.
- Manages storage and erasure of Diagnostic Trouble Codes as well as MIL illumination.
- Controls and co-ordinates the execution of the On-Demand tests: Key On Engine Off (KOEO)Key On Engine Running (KOER), and the Output Test Mode (OTM). For 2008 MY and beyond ISO 14229 programs, the Output Test Mode is no longer supported by the diagnostic executive.
- Performs transitions between various states of the diagnostic and powertrain control system to minimize the effects on vehicle operation.
- Interfaces with the diagnostic test tools to provide diagnostic information (I/M readiness, various J1979 test modes) and responses to special diagnostic requests (J1979 Mode 08 and 09).
- Tracks and manages indication of the driving cycle which includes the time between two key on events that include an engine start and key off.

The diagnostic executive also controls several overall, global OBD entry conditions.

- The battery voltage must fall between 11.0 and 18.0 volts to initiate monitoring cycles.
- The engine must be started to initiate the engine started, engine running, and engine off monitoring cycles.
- The Diagnostic Executive suspends OBD monitoring when battery voltage falls below 11.0 volts.
- The Diagnostic Executive suspends monitoring of fuel-system related monitors (catalyst, misfire, evap, O2, AIR and fuel system) when fuel level falls below 15%. For 2005 MY and beyond, the execution of the fuel related OBD monitors is no longer suspended for fuel level by the diagnostic executive.

The diagnostic executive controls the setting and clearing of pending and confirmed DTCs.

- A pending DTC and freeze frame data is stored after a fault is confirmed on the first monitoring cycle. If the fault recurs on the next driving cycle, a confirmed DTC is stored, freeze frame data is updated, and the MIL is illuminated. If confirmed fault free on the next driving cycle, the pending DTC and freeze frame data is erased on the next power-up.
- For the 2005 MY and later, pending DTCs will be displayed as long as the fault is present. Note that OBD-II regulations required a complete fault-free monitoring cycle to occur before erasing a pending DTC. In practice, this means that a pending DTC is erased on the next power-up after a fault-free monitoring cycle.
- For clearing comprehensive component monitoring (CCM) pending DTCs, the specific monitor must determine that no fault is present, and a 2-hour engine off soak has occurred prior to starting the vehicle. The 2-hour soak criteria for clearing CCM confirmed and pending DTCs has been utilized since the 2000 MY. For 2008 MY and beyond ISO 14229 programs, the engine off soak is no longer used by the diagnostic executive.
- After a confirmed DTC is stored and the MIL has been illuminated, three consecutive confirmed fault-free monitoring cycles must occur before the MIL can be extinguished on the next (fourth) power-up. After 40 engine warm-ups, the DTC and freeze frame data is erased.

The diagnostic executive controls the setting and clearing of permanent DTCs.

- A permanent DTC is stored when a confirmed DTC is stored, the MIL has been illuminated, and there are not yet six permanent DTCs stored.
- After a permanent DTC is stored, three consecutive confirmed fault-free monitoring cycles must occur before the permanent DTC can be erased.
- After a permanent DTC is stored, one confirmed fault-free monitoring cycle must occur, following a DTC reset request, before the permanent DTC can be erased. For 2010MY and beyond ISO 14229 programs a driving cycle including the following criteria must also occur, following the DTC reset request, before a permanent DTC can be erased:
    - Cumulative time since engine start is greater than or equal to 600 seconds;
    - Cumulative vehicle operation at or above 25 miles per hour occurs for greater than or equal to 300 seconds (medium-duty vehicles with diesel engines certified on an engine dynamometer may use cumulative operation at or above 15% calculated load in lieu of at or above 25 miles per hour for purposes of this criteria); and
    - Continuous vehicle operation at idle (i.e., accelerator pedal released by driver and vehicle speed less than or equal to one mile per hour) for greater than or equal to 30 seconds.
- A permanent DTC can not be erased by a KAM clear (battery disconnect). Additionally, its confirmed DTC counterpart will be restored after completion of the KAM reset (battery reconnect).

## Exponentially Weighted Moving Average

Exponentially Weighted Moving Averaging is a well-documented statistical data processing technique that is used to reduce the variability on an incoming stream of data. Use of EWMA does not affect the mean of the data, however, it does affect the distribution of the data. Use of EWMA serves to "filter out" data points that exhibit excessive and unusual variability and could otherwise erroneously light the MIL.

The simplified mathematical equation for EWMA implemented in software is as follows:

New Average = [New data point * "filter constant"] + [( 1 - "filter constant" ) * Old Average]

This equation produces an exponential response to a step-change in the input data. The "Filter Constant" determines the time constant of the response. A large filter constant (i.e. 0.90 ) means that 90% of the new data point is averaged in with 10% of the old average. This produces a very fast response to a step change. Conversely, a small filter constant (i.e. 0.10 ) means that only 10% of the new data point is averaged in with 90% of the old average. This produces a slower response to a step change.

When EWMA is applied to a monitor, the new data point is the result from the latest monitor evaluation. A new average is calculated each time the monitor is evaluated and stored in Keep Alive Memory (KAM). This normally occurs each driving cycle. The MIL is illuminated and a DTC is stored based on the New Average store in KAM.

In order to facilitate repair verification and DDV demonstration, 2 different filter constants are used. A "fast filter constant" is used after KAM is cleared or DTCs are erased and a "normal filter constant" is used for normal customer driving. The "fast filter" is used for 2 driving cycles after KAM is cleared/DTCs are erased, and then the "normal filter" is used. The "fast filter" allows for easy repair verification and monitor demonstration in 2 driving cycles, while the normal filter is used to allow up to 6 driving cycles, on average, to properly identify a malfunction and illuminate the MIL. This feature is called Fast Initial Response (FIR). The fast filter is always calibrated to 1.0 which means that the EWMA is effectively disabled because the new average is 100% of the new data point. Since the EWMA is effectively disabled, it takes twp driving cycles to set the MIL. The first driving cycle with a fault will set a pending DTC; the second driving cycle will set a confirmed code and illuminate the MIL.

The other unique feature used with EWMA is called Step Change Logic (SCL). This logic detects an abrupt change from a no-fault condition to a fault condition. This is done by comparing the new data point to the EWMA old average. If the two points differ by more than a calibrated amount (i.e. the new data point is outside the normal distribution), it means that a catastrophic failure has occurred. The fast filter is then used in the same manner as for the FIR feature above. Since the EWMA is effectively disabled, it takes twp driving cycles to set the MIL. The first driving cycle with a fault will set a pending DTC; the second driving cycle will set a confirmed code and illuminate the MIL. The SCL becomes active after the 4th "normal" monitoring cycle to give the EWMA a chance to stabilize.

During "normal" EWMA operation, a slower filter constant is used. The "normal filer" allows the MIL to be illuminated in 1 to 6 driving cycles. A confirmed code is set and the MIL is illuminated as soon as the EWMA crosses the malfunction threshold. There is no pending DTC because EWMA uses a 1-trip MIL.

In order to relate filter constants to driving cycles for MIL illumination, filter constants must be converted to time constants. The mathematical relationship is described below:

Time constant = [ ( 1 / filter constant ) - 1 ] * evaluation period

The evaluation period is a driving cycle. The time constant is the time it takes to achieve 68% of a step-change to an input. Two time constants achieve 95% of a step change input.

## EWMA Examples

EWMA with FIR and SCL has been incorporated in the catalyst monitor, the Rear O2 response test and the EONV Evaporative system leak check monitor. There are 3 calibrateable parameters that determine the MIL illumination characteristics.

"Fast" filter constant (0.9999), used for 2 driving cycles after DTCs are cleared/KAM is reset (FIR) and for Step Change Logic (SCL)

"Normal" filter constant( typically 0.4),, used for all subsequent, "normal" customer driving

Number of driving cycles to use fast filter after KAM clear (normally set to 2 driving cycles)

Several examples for a typical catalyst monitor calibration are shown in the tables below. The first example does not show SCL in order to better illustrate the EWMA calculation and the 1-trip MIL.

| Monitor evaluation ("new data") | EWMA Filter Calculation, "normal" filter constant set to 0.4 Malfunction threshold = .75 | Weighted Average ("new average") | Driving cycle number | Action/Comment |
|---|---|---|---|---|
| 0.15 | .15 * (0.4) + .15 * ( 1 - 0.4) | 0.15 | | normal 120K system |
| 1.0 | 1.0 * (0.4) + .15 * ( 1 - 0.4) | 0.49 | 1 | large failure occurs |
| 1.0 | 1.0 * (0.4) + .49 * ( 1 - 0.4) | 0.69 | 2 | |
| 1.0 | 1.0 * (0.4) + .69 * ( 1 - 0.4) | 0.82 | 3 | exceeds threshold, MIL on |
| 1.0 | 1.0 * (0.4) + .82 * ( 1 - 0.4) | 0.89 | 4 | MIL on |
| | | | | |
| 0.8 | 0.8 * (0.4) + .15 * ( 1 - 0.4) | 0.41 | 1 | 1.5 * threshold failure |
| 0.8 | 0.8 * (0.4) + .41 * ( 1 - 0.4) | 0.57 | 2 | |
| 0.8 | 0.8 * (0.4) + .57 * ( 1 - 0.4) | 0.66 | 3 | |
| 0.8 | 0.8 * (0.4) + .66 * ( 1 - 0.4) | 0.72 | 4 | |
| 0.8 | 0.8 * (0.4) + .72 * ( 1 - 0.4) | 0.75 | 5 | equals threshold, MIL on |
| 0.8 | 0.8 * (0.4) + .75 * ( 1 - 0.4) | 0.77 | 6 | MIL on |
| | | | | |
| 0.8 | 0.8 * (0.99) + 0* ( 1 - 0.99) | 0.8 | 1 | 1.5 * threshold failure after code clear, pending DTC |
| 0.8 | 0.8 * (0.99) + .8 * ( 1 - 0.99) | 0.8 | 2 | MIL on (I/M Readiness set to "ready" |

## I/M Readiness Code

The readiness function is implemented based on the J1979 format. A battery disconnection or clearing codes using a scan tool results in the various I/M readiness bits being set to a “not-ready” condition. As each non-continuous monitor completes a full diagnostic check, the I/M readiness bit associated with that monitor is set to a “ready” condition. This may take one or two driving cycles based on whether malfunctions are detected or not. The readiness bits for comprehensive component monitoring, misfire and fuel system monitoring are considered complete once all the non-continuous monitors have been evaluated. Because the evaporative system monitor requires ambient conditions between 40 and 100 $^{o}$F and BARO > 22.5 " Hg (< 8,000 ft.) to run, special logic can “bypass” the running the evap monitor for purposes of clearing the evap system I/M readiness bit due to the continued presence of these extreme conditions.

### Evap bypass logic:

If the evaporative system monitor conditions are met with the exception of the 40 to 100 $^{o}$F ambient temperatures or BARO range, a timer is incremented. The timer value is representative of conditions where the Evap monitor could have run (all entry conditions met except IAT and BARO) but did not run due to the presence of those extreme conditions. If the timer continuously exceeds 30 seconds during a driving cycle in which all continuous and non-continuous monitors were evaluated, the evaporative system monitor is then considered complete. If the above conditions are repeated during a second driving cycle, the I/M readiness bit for the evaporative system is set to a “ready” condition.

## Catalyst Temperature Model

A catalyst temperature model is currently used for entry into the catalyst and oxygen sensor monitors. The catalyst temperature model uses various PCM parameters to infer exhaust/catalyst temperature. For the 1998 MY, the catalyst temperature model has been enhanced and incorporated into the Type A misfire monitoring logic. The model has been enhanced to include a misfire-induced exotherm prediction. This allows the model to predict catalyst temperature in the presence of misfire.

The catalyst damage misfire logic (Type A) for MIL illumination has been modified to require that both the catalyst damage misfire rate and the catalyst damage temperature is being exceeded prior to MIL illumination. This change is intended to prevent the detection of unserviceable, unrepeatable, burst misfire during cold engine start-up while ensuring that the MIL is properly illuminated for misfires that truly damage the catalyst.

Beginning with the 2007 MY, the catalyst temperature model is also used to generate the primary inputs to the CSER Monitor as described in that section of this document.

## Serial Data Link MIL Illumination

The instrument cluster on some vehicles uses the CAN data link to receive and display various types of information from the PCM. For example, the engine coolant temperature information displayed on the instrument cluster comes from the same ECT sensor used by the PCM for all its internal calculations.

These same vehicles use the CAN data link to illuminate the MIL rather than a circuit, hard-wired to the PCM. The PCM periodically sends the instrument cluster a message that tells it to turn on the MIL, turn off the MIL or blink the MIL. If the instrument cluster fails to receive a message within a 5-second timeout period, the instrument cluster itself illuminates the MIL. If communication is restored, the instrument cluster turns off the MIL after 5 seconds. Due to its limited capabilities, the instrument cluster does not generate or store Diagnostic Trouble Codes.

# 2013 MY OBD System Operation

# Summary for 6.7L Diesel Engines

Table of Contents

# Introduction – OBD-II and HD OBD

## OBD-II Systems

**On Board Diagnostics II - Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines certified under title 13, CCR section 1968.2**

California OBD-II applies to all California and "CAA Sec. 177 States" for gasoline engine vehicles up to 14,000 lbs. Gross Vehicle Weight Rating (GVWR) starting in the 1996 MY and all diesel engine vehicles up to 14,000 lbs. GVWR starting in the 1997 MY.

"CAA Sec. 177 States" or "California States" are states that have adopted and placed into effect the California Air Resources Board (CARB) regulations for a vehicle class or classes in accordance with Section 177 of the Clean Air Act.. At this time, "CAA Sec. 177 States" are Massachusetts, New York, Vermont and Maine for 2004, Rhode Island, Connecticut, Pennsylvania for 2008, New Jersey, Washington, Oregon for 2009, Maryland for 2011, Delaware for 2014 and New Mexico for 2016. These States receive California-certified vehicles for passenger cars and light trucks, and medium-duty vehicles, up to 14,000 lbs. GVWR."

Federal OBD applies to all gasoline engine vehicles up to 8,500 lbs. GVWR starting in the 1996 MY and all diesel engine vehicles up to 8,500 lbs. GVWR starting in the 1997 MY. US Federal only OBD-certified vehicles may use the US Federal allowance to certify to California OBD II but then turn off/disable 0.020" evap leak detection).

Starting in the 2004 MY, Federal vehicle over 8,500 lbs. are required to phase in OBD-II. Starting in 2004 MY, gasoline-fueled Medium Duty Passenger Vehicles (MDPVs) are required to have OBD-II. By the 2006 MY, all Federal vehicles from 8,500 to 14,000 lbs. GVWR will have been phased into OBD-II.

## Heavy Duty OBD Systems

**Heavy Duty On-Board Diagnostics - Heavy-duty engines (>14,000 GVWR) certified to HD OBD under title 13, CCR section 1971.1(d)(7.1.1) or (7.2.2) (i.e., 2010 and beyond model year diesel and gasoline engines that are subject to full HD OBD)**

Starting in the 2010 MY, California and Federal gasoline-fueled and diesel fueled on-road heavy duty engines used in vehicles over 14,000 lbs. GVWR are required to phase into HD OBD. The phase-in starts with certifying one engine family to HD OBD in the 2010 MY. (2010 MY 6.8L 3V Econoline) By the 2013 MY, all engine families must certify to the HD OBD requirements. Vehicles/engines that do not comply with HD OBD during the phase-in period must comply with EMD+.

OBD-II system implementation and operation is described in the remainder of this document.

# General Description 6.7L Diesel Engine

The 6.7L is a V8 engine designed to meet customer expectations of high horsepower and torque with exceptional fuel economy and low NVH. It must do this while meeting the tough emissions standards set by the EPA and CARB.

Some of the technologies employed to meet these diverse criteria include a Variable Geometry Turbocharger (VGT), common rail fuel injection system, electronically controlled, cooled EGR, a diesel oxidation catalyst (DOC) , Selective Catalytic Reduction catalyst (SCR), Diesel Exhaust Fluid (DEF) injection system, and a diesel particulate filter (DPF).

The system schematic on the next page shows the path of the air as it is compressed by the turbocharger, cooled by the air-to-coolant intercooler, and mixed with the cooled EGR gases. The state of this compressed and heated air is sensed by the manifold absolute pressure (MAP) sensor just before it enters the cylinders and the two temperature sensors that represent Charge Air Cooler Outlet temperature (CACT1) and EGR Cooler outlet temperature (EGRCOT). The exhaust gas pressure is measured by the exhaust backpressure (EP) sensor before it exits through the turbocharger. The exhaust after treatment system consists of a DOC, a SCR, a DPF and a muffler.

An electronic, proportional valve controls EGR rates with an integral position sensor (EGRP). Flows are determined by valve position and the amount that backpressure exceeds boost pressure. An EGR throttle (EGRTP) is used for regeneration control as well as to optimize the boost pressure vs. backpressure levels.

Fuel injection pressure is measured by the high-pressure fuel rail sensor (FRP). Injection pressure is controlled by the high pressure pump and two regulating valves, a Pressure Control Valve (PCV), and a Fuel Metering Unit (MeUn), formerly known as Volume Control Valve (VCV).

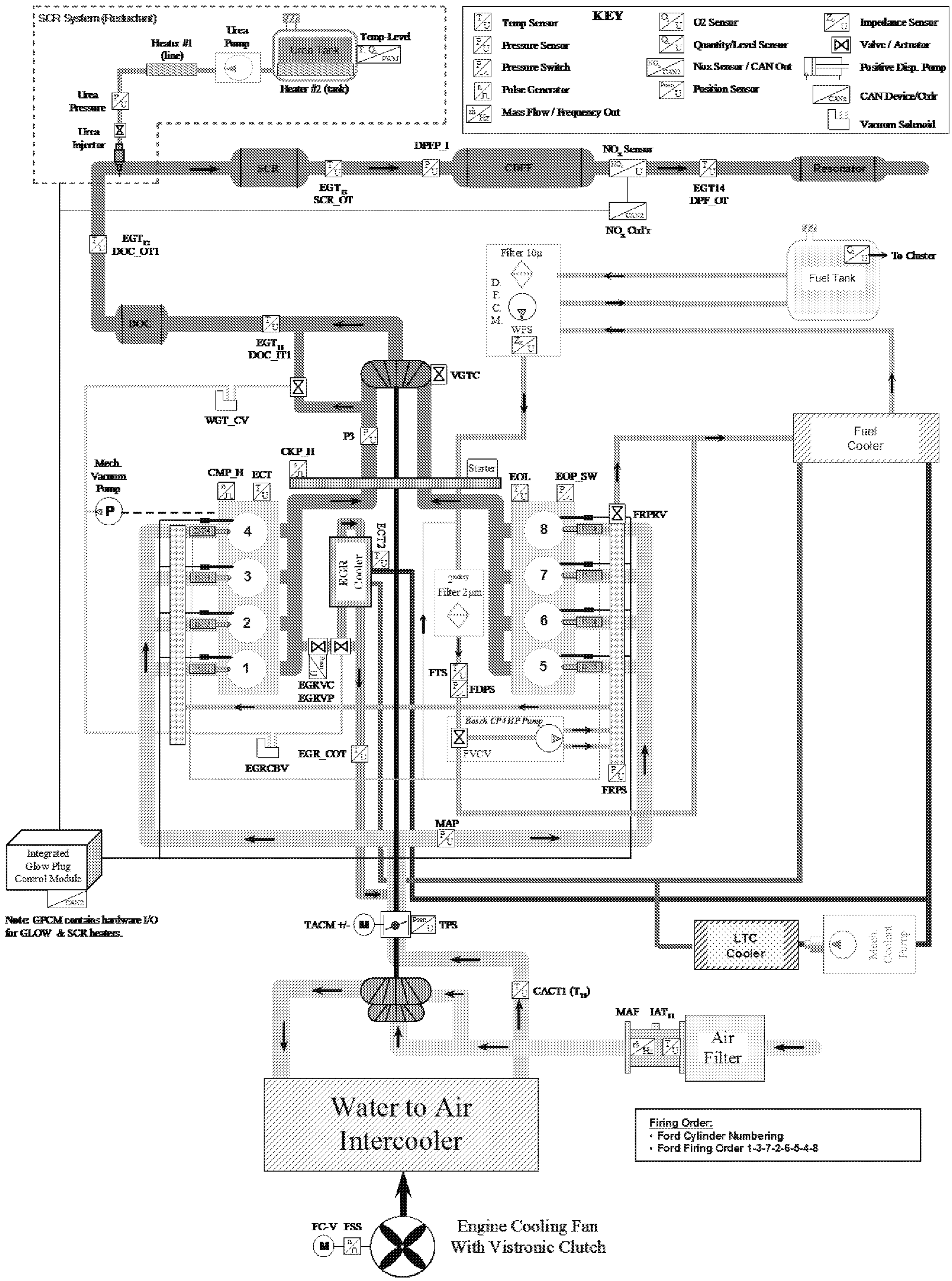
Engine speed (N) and crankshaft position are determined by the crankshaft position sensor (CKP) which senses a 60 minus 2 tooth target wheel. Camshaft position is determined by the camshaft position sensor (CMP), which senses the profile of a multiple lobed camshaft.

Atmospheric pressure is determined by the Barometric Pressure sensor (BARO) mounted internally in the Engine Control Module (ECM).

During engine operation, the ECM calculates engine speed from the crankshaft position sensor. The ECM controls engine operation by controlling the piezo injector opening and closing times as well as the pressure at which the fuel is injected, thereby controlling fuel quantity and timing. Simultaneously, airflow is modulated by controlling the turbocharger vane position.

Fuel quantity is controlled by injector “on time” (pulse width) and the fuel rail pressure. Desired engine speed is determined from the position of the accelerator pedal.

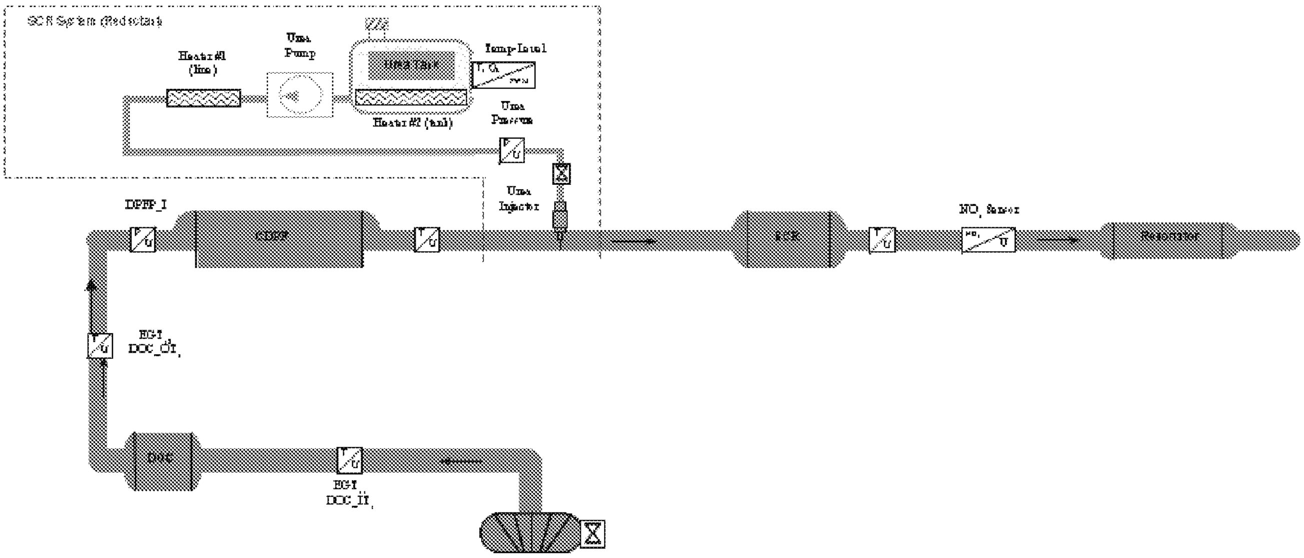
## System Schematic 6.7L Chassis Certified



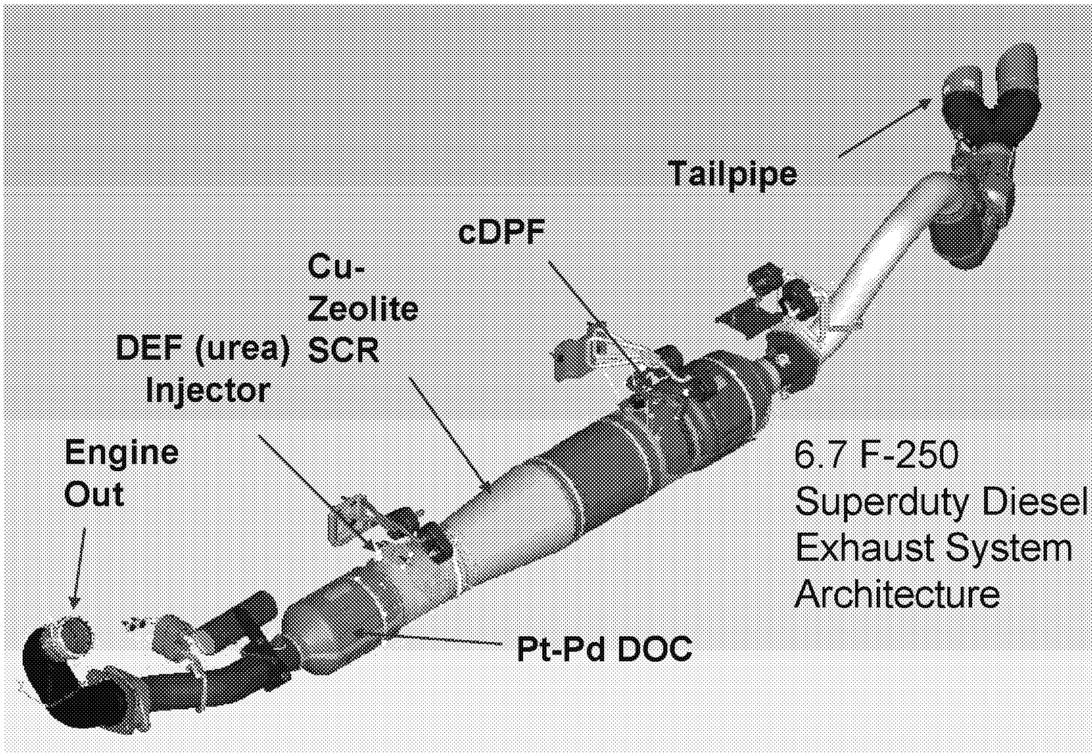
| Actuators | Acronym | Sensors | Acronym |
|---|---|---|---|
| DEF (Reductant) System | | | |
| DEF Pump | | DEF Temp-Level Combination Sensor | |
| DEF Tank Heater | Heater #1 | DEF Pressure Sensor | |
| DEF Pump & Line Heater | Heater #2 | | |
| DEF Injector | | | |
| NOx Sensor System | | | |
| NOx Sensor Controller | | NOx Sensor | |
| Boost System | | | |
| Variable Geometry Turbo Control | VGTC | Manifold Pressure Sensor | MAP |
| Turbocharger Wastegate Vacuum Control Solenoid | WGT_CV | Charge Air Cooler Temperature at Outlet | CACT1 |
| | | Mass Airflow Sensor | MAF |
| | | Intake Air Temperature | IAT11 |
| | | Exhaust Back Pressure | EBP or P3 |
| Exhaust Gas Recirculation System | | | |
| Exhaust Gas Recirculation Valve Control | EGRVC | Exhaust Gas Recirculation Valve Position | EGRVP |
| Exhaust Gas Recirculation Cooler Bypass Vacuum Control Solenoid | EGRCBV | Exhaust Gas Recirculation Cooler Gas Temperature at Outlet | EGR_COT |
| EGR Throttle Motor Control | TACM | EGR Throttle Position Sensor | TPS |
| Fuel System | | | |
| High Pressure Fuel Volume Control Valve | FVCV | High Pressure Fuel Rail Pressure Sensor | FRPS |
| High Pressure Fuel Pressure Relief Valve | FRPRV | Low Pressure Fuel Delivery Switch | FDPS |
| Fuel Injectors | INJ 1-8 | Low Pressure Fuel Temperature Sensor | FTS |
| Low Pressure Fuel Pump and Filters | DFCM | | |
| Water In Fuel Sensor | WFS | | |
| Fuel Tank Level Sensor | | | |
| Glow Plug System | | | |
| Glow Plugs | | | |
| Glow Plug Controller | GPCM | | |
| Exhaust System | | | |
| | | Diesel Oxidation Inlet Temperature | DOC_IT or EGT11 |
| | | Diesel Oxidation Outlet Temperature | DOC_OT or EGT12 |
| | | Selective Catalytic Reduction Outlet Temperature | SCR_OT or EGT 13 |
| | | Upstream Catalyzed Diesel Particulate Filter Pressure | DPFP |
| | | Downstream Diesel Particulate Filter Temperature | DPF_OT or EGT 14 |
| Engine System | | | |
| Electric Clutch Fan Controller | FC-V | Cam Shaft Position Sensor | CMP |
| | | Engine Coolant Temperature | ECT |
| | | Crank Shaft Position Sensor | CKP |
| | | Engine Oil Temperature | EOT |
| | | Engine Oil Pressure Switch | EOP_SW |
| | | Low Temperature Coolant Loop Temperature | ECT2 |
| | | Engine Fan Speed Sensor | FSS |
| | | Environmental Temperature Sensor | ENV_T |
| | | Barometric Pressure Sensor | BP |

The dynamometer certified application of the 6.7L diesel engine has a similar layout to the chassis certified version. The main differences are the use of a single compressor stage on the boost system, lack of a wastegate, and a change in the order of the aftertreatment systems.

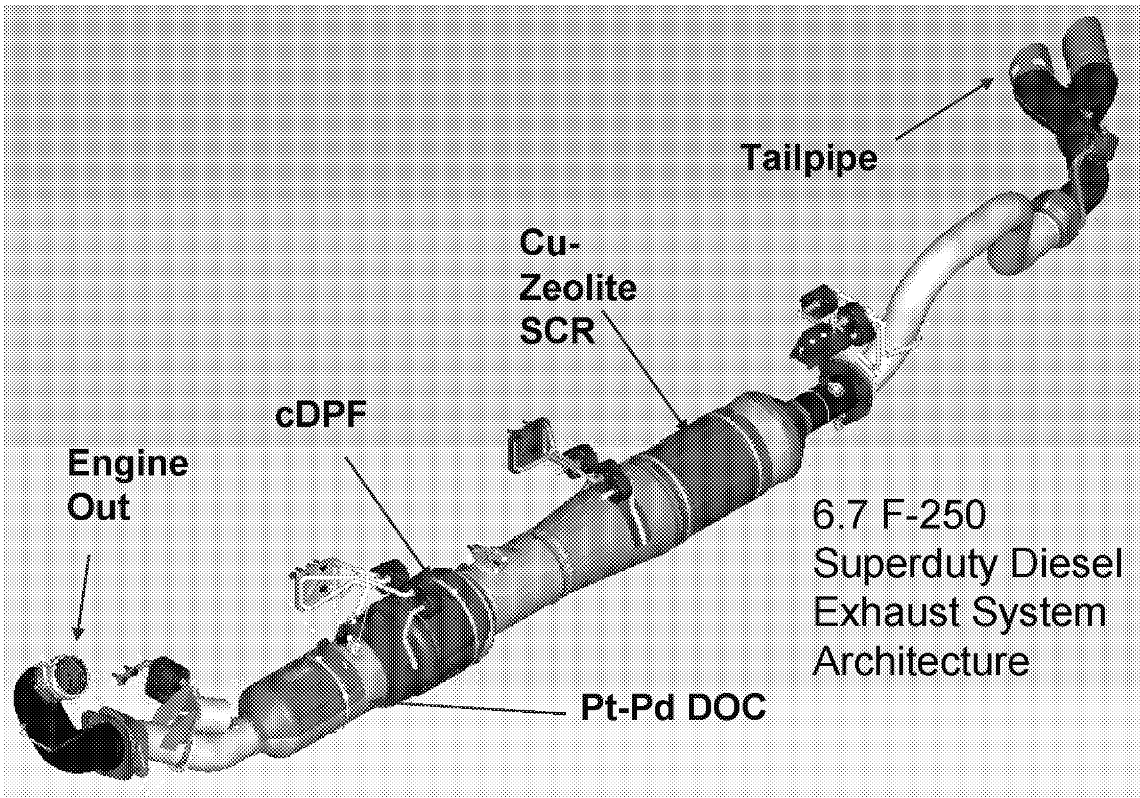
Dynamometer certified 6.7L exhaust system layout.



2013 MY 6.7L V8 Diesel Exhaust Features, Medium Duty, Chassis Cert




2013 MY 6.7L V8 Diesel Exhaust Features, Medium Duty, Dyno Cert



# NON-METHANE HYDROCARBON (NMHC) CONVERTING CATALYST MONITOR

## Diesel Oxidation Catalyst Efficiency Monitor

The Diesel Oxidation Catalyst (DOC) is monitored to ensure it is capable of converting hydrocarbons and carbon monoxide. The monitor is only run during aftertreatment regeneration events. After entering regen, there is a short delay to allow the DOC to achieve light-off temperature. Then the exotherm is monitored for a short period of time and normalized versus an expected exotherm (a function of post-injection fuel quantity and ambient air temp). The exotherm is defined as the DOC outlet temperature (EGT12) minus the DOC inlet temperature (EGT11). The normalized exotherm is filtered for a short period of time, and then compared to a threshold. If the normalized exotherm is below the threshold, a fault is indicated. No other preconditioning is required.

| DOC Efficiency Monitor Summary: | |
|---|---|
| DTCs | P0420 – Catalyst System Efficiency Below Threshold |
| Monitor execution | Once per driving cycle during which an active DPF regeneration occurs |
| Monitor Sequence | None |
| Sensors OK | EGT11, EGT12, TCO, MAF, IAT |
| Monitoring Duration | 4 minutes |

| Typical DOC Efficiency Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| DPF regeneration event | | |
| Engine speed | 1000 rpm | 3000 rpm |
| Torque set point | 100 Nm | 1000 Nm |
| Engine coolant temperature | 70 deg C | |
| DOC inlet temperature | 200 deg C | 500 deg C |
| PTO inactive | | |

| Typical DOC Efficiency Monitor Malfunction Threshold: |
|---|
| Normalized exotherm is less than 40% of the expected exotherm for 60 seconds |

### Diesel Oxidation Catalyst DPF Regeneration Assistance Monitor

The DOC is monitored to ensure it is capable of generating a sufficient exotherm to allow DPF regeneration events by burning the soot which is stored in the Diesel Particulate Filter (DPF). This is accomplished with the same diagnostic described above for the DOC Catalyst Efficiency Monitor.

### Diesel Oxidation Catalyst SCR Assistance Monitor

The DOC in this system is not utilized to provide any changes in the feedgas constituency that would aid in the proper SCR operation.

## OXIDES OF NITROGREN (NOx) CONVERTING CATALYST MONITORING

### Selective Catalyst Reduction Catalyst Efficiency Monitor

The SCR catalyst is monitored to ensure it is capable of NOx conversion. The concentration of NOx upstream of the SCR is calculated based on a model. NOx concentration downstream of the SCR is measured with a NOx sensor. Using these concentrations, the cumulative efficiency of the SCR catalyst is calculated and compared to a threshold. If the cumulative efficiency is below this threshold at the end of the sample period (approx 1 minute), a fault will be indicated.

The reductant, Diesel Exhaust Fluid (DEF), which is used as part of the SCR catalyst reaction, is monitored to ensure the tank is not refilled with an improper reductant. After the SCR Catalyst Efficiency Monitor has completed and the SCR has been determined to be functional, the efficiency monitor continues to calculate the cumulative efficiency of the system, with a calibrated wait time between iterations of the monitor. Successive values for cumulative efficiency are included in two filtering routines, one for short term efficiency and the other for long term efficiency. If the difference between the two filtered efficiencies becomes greater than a threshold, a fault is indicated. The short term efficiency needs to be less than 0.25 and the delta between short and long term efficiency needs to be greater than 0.10.

| Monitor Summary: | |
|---|---|
| DTCs | P20EE – SCR NOx Catalyst Efficiency Below Threshold<br>P207F – Reductant Quality Performance |
| Monitor execution | P20EE - Once per driving cycle<br>P207F – Continuously (while entry conditions are met) |
| Monitor Sequence | P20EE test followed by P207F test |
| Sensors OK | NOx, EGT12, EGT13, ECT, DEF injection system, MAF, BP, O2, DPFP, EGR system |
| Monitoring Duration | P20EE – 2 Minutes, P207F – Dependent on driving conditions and DEF dilution |

| Typical Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| SCR Feedback Control Enabled | | |
| TP NOx sensor lit off and valid | | |
| Regeneration Cycle Not Requested | | |
| Engine coolant temperature | 70 deg C | |
| Ambient air temperature | -6.7 degC | |
| Barometric Pressure | 81.2 kPa | 120 kPa |
| Engine Speed | 1000 rpm | 3000 rpm |
| Torque Transients | -30 N-m/s, | +10 N-m/s |
| Exhaust Space Velocity | 5000 | 120,000 |
| SCR Inlet temp | 180 degC | 320 degC |
| Filtered rate of change of SCR inlet temp | | 30 seconds |
| Feedgas NOx | 75 | 800 |
| DEF storage | 40% understored | 10% overstored |
| Minimum NH3 storage | 0.75 grams | |
| Delay between iterations of monitor (for DEF Quality monitor) | 1400 sec | |
| Short term efficiency<br>(DEF Quality monitor) | | 0.25 |
| Short term to long term efficiency delta<br>(DEF Quality monitor) | 0.1 | |

| Typical Malfunction Thresholds: |
|---|
| P20EE: If the cumulative efficiency of the SCR Catalyst is less than 35% for approx 60 seconds., a fault is indicated.<br><br>P207F: the short term Nox efficiency needs to be less than 0.25 and the delta between short and long term efficiency needs to be greater than 0.10. The fault will generally be detected within 1 hour under most conditions. |

## Selective Catalyst Reduction Feedback Control Monitors

The SCR system is monitored to ensure the proper closed loop control of the reductant injection. As part of the reductant injection control, a correction factor is adapted to account for long term drift of the system (injector, etc). This correction factor is monitored continuously. If the correction factor reaches a threshold in the positive or negative direction for a sufficient period of time, a fault will be indicated.

A SCR Time to Closed Loop monitor is implemented to ensure that SCR feedback occurs when expected. Once entry conditions are met, a timer is incremented. If the fraction of time in closed loop control is less than a threshold, a fault is indicated.

Additionally, the system has a temperature controller that increased the tailpipe temperatures under certain situations to improve the function of the SCR system. This controller is also monitored.

| Monitor Summary: | |
|---|---|
| DTCs | P249D – SCR Feedback at Minimum Limit<br>P249E – SCR Feedback at Maximum Limit<br>P249C – SCR Time to Closed Loop |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | NOx, EGT12, EGT13,TCO, EGT11 EGT14, MAF, BP, IAT, DPFP, and EGR system |
| Monitoring Duration | 5 minutes |

| Typical Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Low Temp Adaptation is enabled (Feedback monitor only) | | |
| Engine speed | 800 rpm | 3000 rpm |
| Torque set point | 0 Nm | 1000 Nm |
| Barometric pressure | 74.5 kPa | |
| Ambient temperature | -6.7 deg C | |
| Engine coolant temperature | 70 deg C | |
| SCR temperature | 160 deg C | 550 deg C |

| Typical Malfunction Thresholds: |
|---|
| P249D: If the correction factor is clipped at its minimum value for 30 seconds then a fault is indicated.<br><br>P249E: If the correction factor is clipped at its maximum value for 30 seconds then a fault is indicated.<br><br>P249C: The error is set as soon as the fraction of closed loop operation vs expected is less than the threshold. The monitor needs to run for 300 seconds to call it complete. |

## Exhaust Temperature Controller Monitor

The monitoring of exhaust temperature is done by comparing the temperature deviation in between the setpoint temperature and the actual measured temperature with a maximum allowed deviation threshold.

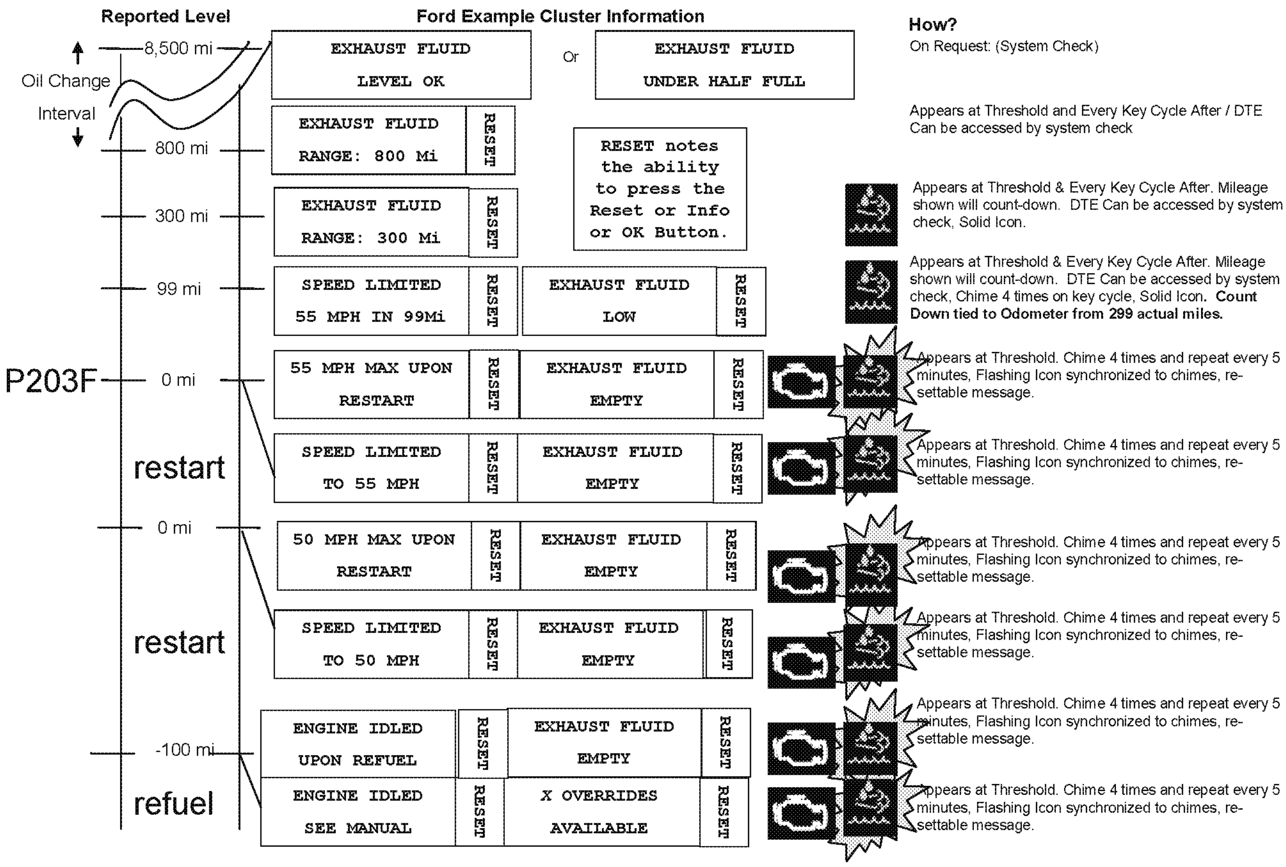
| Monitor Summary: | |
|---|---|
| DTCs | P22FF – SCR NOx Catalyst Inlet Temperature Too Low |
| Monitor execution | Continuous while entry conditions are meet |
| Monitor Sequence | None |
| Sensors OK | EGT12, ECT, BP, ENV_T, CKP, EGR system, Fuel injection system, PCV, |
| Monitoring Duration | 300 seconds - Dependent on driving condtions |

| Typical Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Low Temp Adaptation is enabled (Feedback monitor only) | | |
| Engine speed | 0 rpm | 5400 rpm |
| Torque set point | 0 Nm | 2700 Nm |
| Barometric pressure | 80 kPa | |
| Ambient temperature | 2.96 deg C | |
| Engine coolant temperature | 17.46 deg C | |

| Typical Malfunction Thresholds: |
|---|
| P22FF: the error is set if the difference between scr temp calculated and measured is below 80 deg C for 300 seconds |

## Selective Catalyst Reduction Tank Level

The SCR system is monitored to ensure the level of DEF in the reductant tank is sufficient to achieve system performance. As part of the DEF level customer warning system, a fault will be recorded when the calculated mileage remaining of DEF is equal to 200 miles (The discrepancy between actual and reported mileage is due to expected tolerance of calculations). The calculated mileage remaining is derived from the three pin level sensor in the tank and the volume of DEF commanded to be injected over distance. This fault will be erased once the system senses a DEF refill event.




DEF Override countdown 5-4-3-2-1-NO

| Monitor Summary: | |
|---|---|
| DTCs | P203F - Reductant Level Too Low |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | DEF Temp-Level Combination Sensor |

# MISFIRE MONITOR

## Misfire System Overview

The 6.7L Diesel engine utilizes a Hall Effect sensor (CKP) that processes the edges of a 60-2 tooth stamped target wheel mounted on the crankshaft. The software gets an edge every 3 degrees and these edges are used for fuel injection timing, fuel quantity control, and the calculation of engine speed. A software algorithm corrects for irregularities of the teeth of the target wheel to improve crankshaft signal resolution. A second Hall effect sensor is used to processes the edges of the three-lobed camshaft (CMP) target. The CMP signal and the window of 2 missing teeth on the crankshaft target wheel indicate proper camshaft to crankshaft position for correct cylinder timing.

## Misfire Algorithm Processing

The Misfire Monitor divides two rotations of the crankshaft into 16 half-segments, each 45 degrees of crankshaft rotation. The crankshaft speed shows increases due to combustion of fuel in the cylinder followed by decreases due to friction and other forces between cylinder firing events. The location of the half-segments is chosen such that for each cylinder one half-segment contains the majority of the higher crankshaft speed values (the "high" half-segment) and the other half-segment the majority of the lower crankshaft speed values (the "low" half-segment). The range of crankshaft speed within each half-segment is averaged. The sum of the eight low half-segment speeds is subtracted from the sum of the eight high half-segment speeds and the result divided by eight to get an average increase in speed due to combustion. The Misfire Monitor then calculates the difference between the high and low half-segments for a specific cylinder combustion event and increments a misfire counter for the firing cylinder if this value is less than 20% of the average increase in speed due to combustion described above.

The Misfire Monitor collects blocks of data consisting of 20 crankshaft rotations. Upon achieving the correct entry conditions for the Misfire Monitor as described below, the first block of 20 rotations is discarded to ensure stable idle operation. All subsequent blocks of data are counted unless vehicle conditions change such that the entry conditions are no longer satisfied. In this case, any data in the current partial block are discarded, along with the data from the block immediately prior, as stable idle cannot be ensured for these data. The Misfire Monitor completes once 50 valid blocks (1000 crankshaft revolutions) have been collected, and a fault is reported if a cylinder shows 350 or more misfire events (out of 500 possible combustion events) in this time.

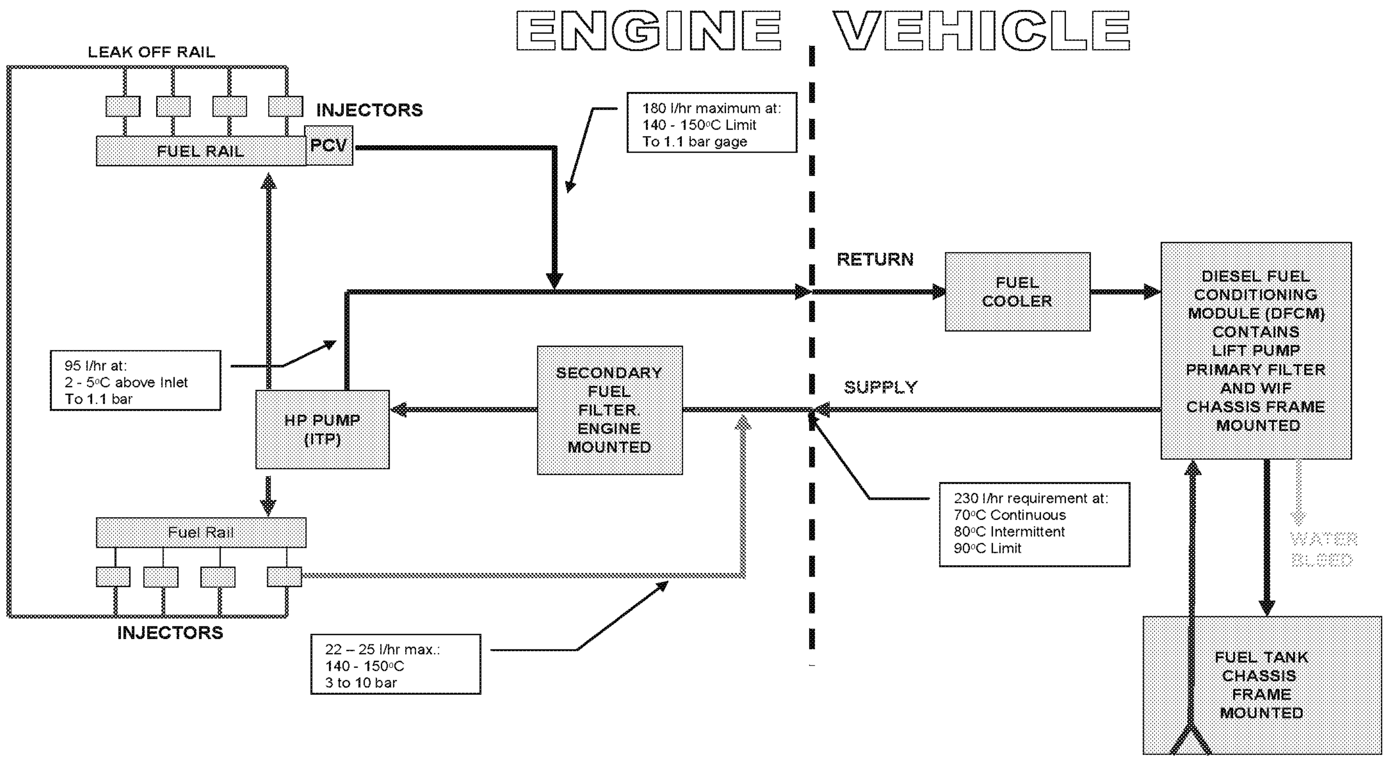
Certain engine operating parameters are monitored to ensure misfire operates in a region that yields accurate misfire results. The table below outlines the entry conditions required for executing the misfire monitor algorithm.

| Misfire Monitor Operation: | |
|---|---|
| DTCs | P0300 – Random Misfire Detected<br>P0301 – Cylinder 1 Misfire Detected<br>P0302 – Cylinder 2 Misfire Detected<br>P0303 – Cylinder 3 Misfire Detected<br>P0304 – Cylinder 4 Misfire Detected<br>P0305 – Cylinder 5 Misfire Detected<br>P0306 – Cylinder 6 Misfire Detected<br>P0307 – Cylinder 7 Misfire Detected<br>P0308 – Cylinder 8 Misfire Detected |
| Monitor execution | Continuous, at idle |
| Monitor Sequence | None |
| Sensors OK | Engine Coolant Temperature (ECT), Vehicle Speed (VSS), Crankshaft Position Sensor (CKP) Injector Faults, Injector Bank Faults |
| Monitoring Duration | 1000 revs |

| Typical Misfire Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Speed (Idle) | 500 rpm | 1150 rpm |
| Engine Coolant Temperature (ECT) | -7 deg C | |
| Vehicle Speed (VSS) | | <= 2 km/hr |
| Total fuel mass | 2.0 mg/stroke | 40.0 mg/stroke |

## Fuel System Overview

Fuel injection pressure is measured by the high-pressure fuel rail sensor (FRP). Injection pressure is controlled by the high pressure pump and two regulating valves, a Pressure Control Valve (PCV), and a Fuel Metering Unit (MeUn), formerly known as Volume Control Valve (VCV).




## Fuel Rail Pressure Sensor Circuit Check

| Fuel Rail Pressure ( FRP ) Sensor Circuit Check: | |
|---|---|
| DTCs | P0192 - Fuel Rail Pressure Sensor A Circuit Low Input<br>P0193 - Fuel Rail Pressure Sensor A Circuit High Input |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Sensor Supply Voltage 1 OK (P06A6) |
| Typical Monitoring Duration | 0.5 sec |

| Typical Fuel Rail Pressure Sensor Circuit Check Malfunction Thresholds: |
|---|
| FRP voltage < 0.13 V, or > 3.17 V |

| Fuel Rail Pressure ( FRP ) Rationality Check Operation: | |
|---|---|
| DTCs | P0191 - Fuel Rail Pressure Sensor "A" Circuit Range/Performance |
| Monitor Execution | Immediately Prior to Crank and After Key-off |
| Monitor Sequence | None |
| Sensors OK | Sensor Supply Voltage 1 OK (P06A6), FRP OK (P0192, P0193) |
| Typical Monitoring Duration | 0.5 sec |

| Typical Fuel Rail Pressure Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Pre-crank: engine coolant temperature | -7 deg C | |
| Pre-crank: time engine off | 600 sec | |
| After key-off: fuel temperature | -40 deg C | |
| After key-off: time since key off | 12 sec | |

| Typical Fuel Rail Pressure Rationality Malfunction Thresholds: |
|---|
| FRP voltage < 0.251 V (-40 bar) or > 0.384 V (68 bar). |

## Fuel Rail Pressure Sensor Range Check:

When fuel rail pressure is controlled by the Pressure Control Valve, the Pressure Control Valve signal needed to maintain rail control is compared to an expected value. An adaptation factor for the Pressure Control Valve is calculated from the difference between observed and expected control values. Inaccuracy in the Rail Pressure Sensor Signal Slope is a potential cause of inaccuracy in the needed Pressure Control Valve signal along with physical errors in the PCV itself. If the adaptation factor required for the Pressure Control Valve exceeds a minimum or maximum control limit, then a code is set for rail pressure slope out of acceptable range.

| Fuel Rail Pressure ( FRP ) Range Check Operation: | |
|---|---|
| DTCs | P016D - Excessive Time To Enter Closed Loop Fuel Pressure Control<br>P228E - Fuel Pressure Regulator 1 Exceeded Learning Limits - Too Low<br>P228F - Fuel Pressure Regulator 1 Exceeded Learning Limits - Too High |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Sensor Supply Voltage 1 (P06A6), FRP (P0192, P0193) |
| Typical Monitoring Duration | P016D – 30 sec, P228E, P228F - 10 sec |

| Typical Fuel Rail Pressure Range Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| P016D: | | |
| Requested rail pressure | 500 bar | 1200 bar |
| Change in requested rail pressure | | 30 sec |
| Fuel temperature | | 40 deg C |
| P228E, P228F: | | |
| Rail pressure set point | 500 bar | 1200 bar |
| Fuel Temperature | | 40 deg C |
| Time since engine start | | 30 sec |

| Typical Fuel Rail Pressure Range Check Malfunction Thresholds: |
|---|
| P016D: If the system is within the adaptation operating conditions, but fails to learn a new adaptation factor after 30 seconds, this DTC is set.<br>P228E, P228F: If the adaptation factor exceeds positive or negative thresholds which correspond to approximately a 20% deviation in the Rail Pressure Sensor slope, a DTC is set. |

| Fuel Temperature Sensor Circuit Check Operation: | |
|---|---|
| DTCs | P0181 – Fuel Temperature Sensor "A" Circuit Range/Performance<br>P0182 – Fuel Temperature Sensor "A" Circuit Low<br>P0183 – Fuel Temperature Sensor "A" Circuit High |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | None |
| Typical Monitoring Duration | 0.5 sec |

| Typical Fuel Temperature Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| P0181: | | |
| Engine Off Time | 8 hours | |

| Typical Fuel Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| P0181: If after an 8 hour engine off soak, the difference in temperature between the fuel temperature sensor and the charge air cooler outlet temperature sensor exceeds 16 deg C or if the difference in temperature between the fuel temperature sensor and the charge air cooler outlet temperature sensor exceeds 13.2 deg C and no active block heater is detected, a DTC is set<br>FTS voltage < 0.0946 V (0.122.4 V = 150 deg C) or > 4.918 V (4.762 V = -40 deg C) |

| Volume Control Valve (VCV) Monitor Operation: | |
|---|---|
| DTCs | P0001 - Fuel Volume Regulator Control Circuit / Open<br>P0002 - Fuel Volume Regulator Control Circuit Range/Performance<br>P0003 - Fuel Volume Regulator Control Circuit Low<br>P0004 - Fuel Volume Regulator Control Circuit High |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | None |
| Typical Monitoring Duration | 0.3 sec |

| Typical Volume Control Valve Monitor Malfunction Thresholds: |
|---|
| P0001 – If the volume control valve is not energized and the voltage from the volume control valve control chip is in the range 2.8 – 4.8 V (normal operation: electrical system voltage (~13.5V)<br>P0002 – Temperature of powerstage driver on ECM > 170 deg C<br>P0003 – If the volume control valve is not energized and the observed voltage from the volume control valve control chip is less than 2.8V (normal operation: electrical system voltage (~13.5V)<br>P0004 – If the volume control valve is energized and the current to the volume control valve exceeds 3.7A (normal operation: 2.2A maximum) |

| Fuel Pressure Control Valve (PCV) Monitor Operation: | |
|---|---|
| DTCs | P0089 - Fuel Pressure Regulator Performance<br>P0090 - Fuel Pressure Regulator Control Circuit<br>P0091 - Fuel Pressure Regulator Control Circuit Low<br>P0092 - Fuel Pressure Regulator Control Circuit High |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | None |
| Typical Monitoring Duration | 0.3 sec |

| Typical Fuel Pressure Control Valve Monitor Malfunction Thresholds: |
|---|
| P0089 – Temperature of power stage driver on ECM is > 170 deg C<br>P0090 – The pressure control valve is not energized and the voltage from the pressure control valve control chip is in the range 2.8 – 4.8 V (normal operation: electrical system voltage (~13.5V)<br>P0091 – The pressure control valve is not energized and the voltage from the pressure control valve control chip is less than 2.8V (normal operation: electrical system voltage (~13.5V)<br>P0092 – The pressure control valve is energized and the observed current to the pressure control valve exceeds 5.1A (normal operation: 3.7A maximum) |

| Fuel Low Pressure Lift Pump Monitor Operation: | |
|---|---|
| DTCs | P0627 - Fuel Pump "A" Control Circuit / Open<br>P0628 - Fuel Pump "A" Control Circuit Low<br>P0629 - Fuel Pump "A" Control Circuit High<br>P062A – Fuel Pump "A" Control Circuit Range/Performance |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | None |
| Typical Monitoring Duration | P0627, P0628, P0629 - 0.2 sec<br>P062A – 0.5 sec |

| Typical Fuel Low Pressure Lift Pump Monitor Malfunction Thresholds: |
|---|
| P0627 – Lift pump NOT energized and the voltage from the lift pump control chip is between 2.8 – 4.8V (normal operation: electrical system voltage ~13.5V) |
| P0628 – Lift pump NOT energized and the voltage from the lift pump control chip is less than 2.8V (normal operation: electrical system voltage ~13.5V) |
| P0629 – Lift pump energized and the current to the lift pump exceeds 3.7A (normal operation: 2.2A maximum) |
| P062A – If the airbag deployment module sends a deployment signal and the fuel pump shows as energized via the fuel pump monitor signal or the status of the energizing request to the fuel pump and the monitoring signal from the fuel pump does not match |

| Fuel Injector Driver Circuit Monitor Operation: | |
|---|---|
| DTCs | P062D - Fuel Injector Driver Circuit Performance Bank 1<br>P062E - Fuel Injector Driver Circuit Performance Bank 2<br>P1291 - Injector High Side Short To GND Or VBATT (Bank 1)<br>P1292 - Injector High Side Short To GND Or VBATT (Bank 2) |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | None |
| Typical Monitoring Duration | P062D, P062E – 0.5 seconds<br>P1291, P1292 – 0.2 seconds |

| Typical Fuel Injector Driver Circuit Malfunction Thresholds: |
|---|
| P062D, P062E – Failure of injector driver of bank detected by IC Internal logic |
| P1291, P1292 – Short to ground or battery of bank detected by IC internal logic |

| Injection Circuits Monitor Operation: | |
|---|---|
| DTCs | P0201 - Injector Circuit / Open - Cylinder 1<br>P0202 - Injector Circuit / Open - Cylinder 2<br>P0203 - Injector Circuit / Open - Cylinder 3<br>P0204 - Injector Circuit / Open - Cylinder 4<br>P0205 - Injector Circuit / Open - Cylinder 5<br>P0206 - Injector Circuit / Open - Cylinder 6<br>P0207 - Injector Circuit / Open - Cylinder 7<br>P0208 - Injector Circuit / Open - Cylinder 8<br>P02EE – Cylinder 1 Injector Circuit Range/Performance<br>P02EF – Cylinder 2 Injector Circuit Range/Performance<br>P02F0 – Cylinder 3 Injector Circuit Range/Performance<br>P02F1 – Cylinder 4 Injector Circuit Range/Performance<br>P02F2 – Cylinder 5 Injector Circuit Range/Performance<br>P02F3 – Cylinder 6 Injector Circuit Range/Performance<br>P02F4 – Cylinder 7 Injector Circuit Range/Performance<br>P02F5 – Cylinder 8 Injector Circuit Range/Performance<br>P1201 – Cylinder #1 Injector Circuit Open/Shorted<br>P1202 – Cylinder #2 Injector Circuit Open/Shorted<br>P1203 – Cylinder #3 Injector Circuit Open/Shorted<br>P1204 – Cylinder #4 Injector Circuit Open/Shorted<br>P1205 – Cylinder #5 Injector Circuit Open/Shorted<br>P1206 – Cylinder #6 Injector Circuit Open/Shorted<br>P1207 – Cylinder #7 Injector Circuit Open/Shorted<br>P1208 – Cylinder #8 Injector Circuit Open/Shorted<br>P1261 – Cylinder #1 High To Low Side Short<br>P1262 – Cylinder #2 High To Low Side Short<br>P1263 – Cylinder #3 High To Low Side Short<br>P1264 – Cylinder #4 High To Low Side Short<br>P1265 – Cylinder #5 High To Low Side Short<br>P1266 – Cylinder #6 High To Low Side Short<br>P1267 – Cylinder #7 High To Low Side Short<br>P1268 – Cylinder #8 High To Low Side Short |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | None |
| Typical Monitoring Duration | P0201 – P0208 – 0.3 seconds.<br>P02EE – P2F5 – 0.3 seconds.<br>P1201 – P1208 – 0.3 seconds.<br>P1261 – P1268 – 0.3 seconds. |

| Typical Injection Circuits Malfunction Thresholds: |
|---|
| P0201 – P0208 – Injector open circuit detected by IC internal logic<br>P02EE – P02F5 – Implausible injector response detected by IC internal logic<br>P1201 – P1208 – Injector short circuit detected by IC internal logic<br>P1261 – P1268 – Injector high side to low side short circuit detected by IC internal logic |

## Injector Code Missing/Invalid:

| Injector Code Monitor Operation: | |
|---|---|
| DTCs | P268C – Cylinder 1 Injector Data Incompatible<br>P268D – Cylinder 2 Injector Data Incompatible<br>P268E – Cylinder 3 Injector Data Incompatible<br>P268F – Cylinder 4 Injector Data Incompatible<br>P2690 – Cylinder 5 Injector Data Incompatible<br>P2691 – Cylinder 6 Injector Data Incompatible<br>P2692 – Cylinder 7 Injector Data Incompatible<br>P2693 – Cylinder 8 Injector Data Incompatible |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | None |
| Typical Monitoring Duration | 0.5 seconds |

| Typical Injector Code Monitor Malfunction Thresholds: |
|---|
| P268C – P2693: Each injector has a code stored in EEPROM that provides information to the ECU about deviations of that injector from a theoretical average injector. If the injector code is missing or invalid, a DTC is set. |

## Fuel system pressure control:

### Fuel Rail Pressure Monitors:

The pressure in the fuel rail is controlled by a closed-loop control strategy that is always active during vehicle operation. Two controllers may be used to control the rail pressure: the Pressure Control Valve and the Volume Control Valve. The Pressure Control Valve is used to control pressure at engine start and when fuel temperature is low. The Volume Control Valve is used to control fuel pressure under most other conditions. A third operation mode allows fuel rail pressure to be controlled by a combination of the Pressure Control Valve and Volume Control Valve; this mode is typically used to transition from control by one device to the other and in regimes where low fuel volume is required.

The fuel rail pressure is controlled either with the Pressure Control Valve, the Volume Control Valve, or both, depending upon engine operation condition. The high and low Fuel Rail Pressure Monitors detect when there is an excessive deviation from the desired fuel pressure when the controller has reached a control limit or when the minimum or maximum allowable rail pressures are exceeded. A code is set for Fuel Pressure Regulator Performance when the system is using both the Pressure Control Valve and the Volume Control Valve to regulate rail pressure and the rail pressure becomes too high, indicating a problem with the Pressure Control Valve.

| Fuel Rail Pressure ( FRP ) Monitor Operation: | |
|---|---|
| DTCs | P0087 - Fuel Rail/System Pressure - Too Low<br>P0088 - Fuel Rail/System Pressure – Too High<br>P0089 - Fuel Pressure Regulator Performance<br>P0093 – Fuel System Leak Detected – Large Leak |
| Monitor Execution | Continuos |
| Monitor Sequence | None |
| Sensors OK | FRP (P0191, P0192, P0193) |
| Typical Monitoring Duration | P0087, P0088 – 1.4 sec<br>P0089 – 1.0 sec<br>P0093 – 2 sec |

| Typical Fuel Rail Pressure Monitor Malfunction Thresholds: |
|---|
| P0087: If the commanded rail pressure exceeds the measured rail pressure by 250 bar for 1.4 sec or if the measured rail pressure drops below 140 bar for 0.3 sec |
| P0088: If the measured rail pressure exceeds the commanded rail pressure by 250 bar for 1.4 sec or if the measured rail pressure exceeds 2150 bar for 0.3 sec |
| P0089: If measured rail pressure exceeds commanded rail pressure by 490 bar for 1.0 sec |
| P0093: If the set point needed for the volume control valve to maintain desired rail pressure exceeds 13,500 mm3/sec at idle or if the set point needed for the volume control valve to maintain desired rail pressure is 40% greater than the volume control valve set point as calculated from the requested injection quantity when not at idle |

## Injection Timing / Injection quantity

### Zero Fuel Calibration:

Zero Fuel Calibration (ZFC) is an algorithm used to detect deviations in individual injector performance from nominal. In an overrun/decel fuel shut-off condition, fuel rail pressure is set to 300 bar and small injections are made from a single injector. The observed acceleration in crankshaft speed is detected and a regression line generated to predict the fueling required to achieve the expected acceleration. If the calculated fueling required to generate the expected acceleration in crankshaft speed falls outside the allowable control limits for the system, an addition routine is called to very precisely learn the adjustment to injector energizing time required to achieve expected acceleration. This information is then used to adjust all pilot injections on that injector to ensure correct fuel delivery. If the absolute energizing time observed for the test injection to yield the expected acceleration exceeds minimum or maximum limits, a code is set.

| Zero Fuel Calibration (ZFC) Monitor Operation: | |
|---|---|
| DTCs | P02CC – Cylinder 1 Fuel Injector Offset Learning at Min Limit<br>P02CD – Cylinder 1 Fuel Injector Offset Learning at Max Limit<br>P02CE – Cylinder 2 Fuel Injector Offset Learning at Min Limit<br>P02CF – Cylinder 2 Fuel Injector Offset Learning at Max Limit<br>P02D0 – Cylinder 3 Fuel Injector Offset Learning at Min Limit<br>P02D1 – Cylinder 3 Fuel Injector Offset Learning at Max Limit<br>P02D2 – Cylinder 4 Fuel Injector Offset Learning at Min Limit<br>P02D3 – Cylinder 4 Fuel Injector Offset Learning at Max Limit<br>P02D4 – Cylinder 5 Fuel Injector Offset Learning at Min Limit<br>P02D5 – Cylinder 5 Fuel Injector Offset Learning at Max Limit<br>P02D6 – Cylinder 6 Fuel Injector Offset Learning at Min Limit<br>P02D7 – Cylinder 6 Fuel Injector Offset Learning at Max Limit<br>P02D8 – Cylinder 7 Fuel Injector Offset Learning at Min Limit<br>P02D9 – Cylinder 7 Fuel Injector Offset Learning at Max Limit<br>P02DA – Cylinder 8 Fuel Injector Offset Learning at Min Limit<br>P02DB – Cylinder 8 Fuel Injector Offset Learning at Max Limit<br>P262A – Fuel Injector – Pilot Injection Not Learned |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Typical Monitoring Duration | P262A – 5 sec, all other DTCs 30 sec |

| Typical Zero Fuel Calibration (ZFC) Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| P02CC, P02CD, P02CE, P02CF, P02D0, P02D1, P02D2, P02D3, P02D4, P02D5, P02D6, P02D7, P02D8, P02D9, P02DA, P02DB, P262A: | | |
| Intake air temperature | 0 deg C | |
| Fuel temperature | 10 deg C | 75 deg C |
| Engine coolant temperature | 50 deg C | |
| System voltage | 10 V | |
| Time in overrun/decel fuel shut-off | | 30 sec |
| Engine speed | 890 rpm | 1610 rpm |
| Boost pressure | 750 mbar | |
| Accelerator pedal | | 2 % |
| Transmission gear (no gear change) | 4 th | 6 th |
| Torque converter locked | | |
| Fuel Balance Control wheel learn complete | | |
| Note: these are the entry conditions for the base function. The monitor runs whenever the base function runs. | | |

| Typical Zero Fuel Calibration (ZFC) Monitor Malfunction Thresholds: |
| --- |
| P02CC, P02CE, P02D0, P02D2, P02D4, P02D6, P02D8, P02DA:<br>If the observed energizing time for the test injection is 156 us or more lower than the target 430 us energizing time for the given injector, the code is set.<br>P02CD, P02CF, P02D1, P02D3, P02D5, P02D7, P02D9, P02DB:<br>If the observed energizing time for the test injection is 254 us or more higher than the target 430 us energizing time for the given injector, the code is set.<br>P262A:<br>When the entry conditions described above are satisfied, if the system is unable to learn any data for pilot injection correction for 100 seconds, this code is set. |

## Fuel Mass Observer: (Global Fuel Bias)

Fuel Mass Observer (FMO) is an algorithm used to detect deviations in performance of all injectors from nominal. The oxygen percentage as measured by the tailpipe oxygen sensor is compared to a modeled oxygen percentage based upon current fuel, boost, and EGR settings. Deviation between the observed and modeled oxygen percentage is expressed in terms of the error in fueling required to explain the deviation. This calculated error in fueling is then divided by the current requested fueling level to generate a ratio of percentage error in fueling. This fueling ratio is then filtered over time. If the filtered error in fueling ratio exceeds minimum or maximum limits, then a code is set.

| Fuel Mass Observer (FMO) Monitor Operation: | |
|---|---|
| DTCs | P016A - Excessive Time To Enter Closed Loop Air/Fuel Ratio Control<br><br>P0170 – Fuel Trim (Bank 1) |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Typical Monitoring Duration | P016A – 50 s; P0170 - 180 sec |

| Typical Fuel Mass Observer (FMO) Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine speed | 1000 rpm | 3000 rpm |
| Fuel injection quantity | 20 mg/stroke | 80 mg/stroke |
| Ambient pressure | 700 hPa | |
| System voltage | 9 V | |
| Ambient temperature | -5 C | |
| Tailpipe oxygen sensor status | Ready | |
| Post injection | Not occurring | |

| Typical Fuel Mass Observer (FMO) Monitor Malfunction Thresholds: |
|---|
| P016A – If above entry conditions are met and calculation of error in fueling due to difference between observed and modeled tailpipe oxygen concentration is not occurring, this fault is set<br><br>P0170 : if the absolute value of the filtered ratio of error in fueling exceeds 0.19, this code is set. |

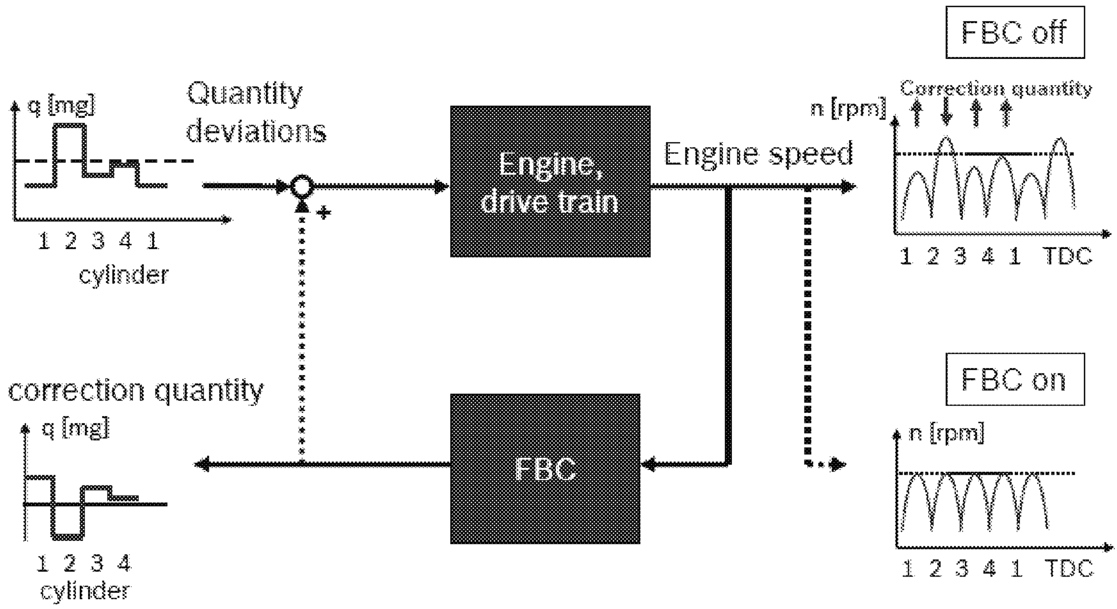
## Global Fuel Timing:

Errors in the control system that would result in a timing shift of the fuel injectors is diagnosed by looking at the cam to crank shaft alignment as discussed in the section for P0016.

## Feedback control:

### Fuel Balancing Control:

Fuel Balancing Control is an algorithm designed to reduce differences in injected fuel quantity from cylinder to cylinder. The increase in crankshaft speed due to individual cylinder combustion events is measured. The amount of fuel injected to each cylinder is then adjusted up or down to minimize the difference in increase in crankshaft speed from cylinder to cylinder. The total amount of fuel injected among all cylinders remains constant. The concept is shown in the graphic below.




FBC operates in closed-loop control in an engine speed range of 500-3000 rpm, and a commanded injection quantity of 3.5 – 90 mg/stroke. The maximum allowed correction in fuel quantity for an individual cylinder is given by the following table.

| Fuel Balancing Control (FBC) Control Limits: | | | |
|---|---|---|---|
| | Injection quantity requested before FBC correction (mg/stroke) | | |
| Maximum allowable FBC correction (mg/stroke): | 3.5 | 7.5 | 15 |
| | 4 | 8 | 15 |

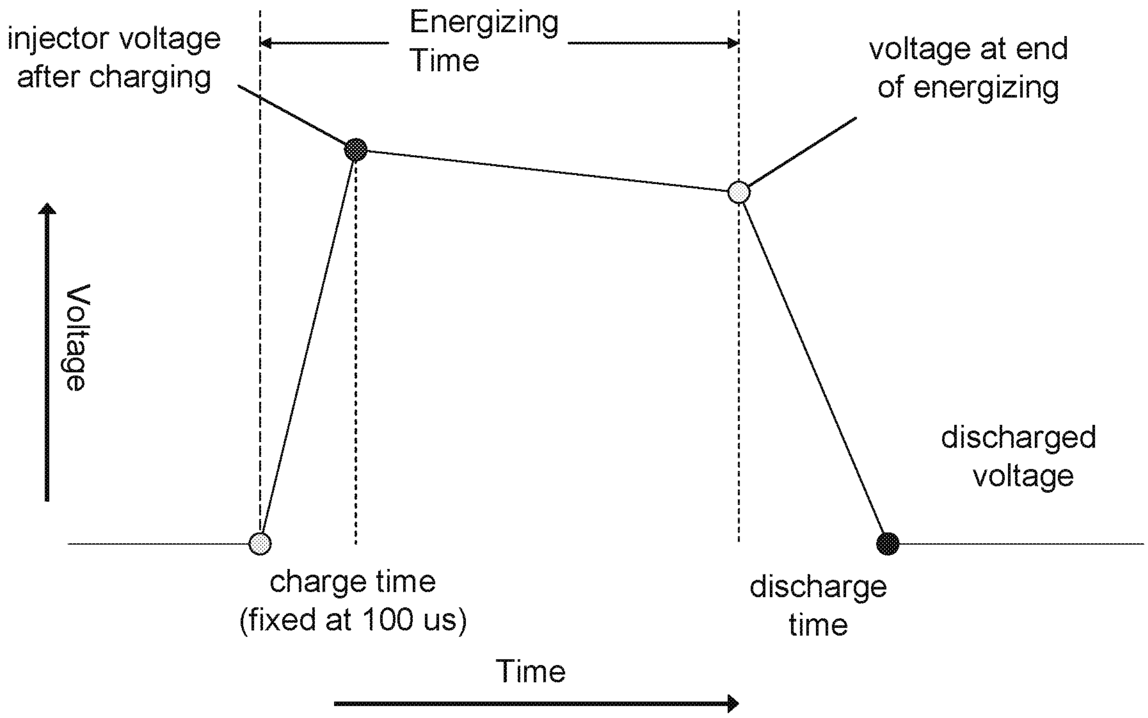
| Fuel Balancing Control (FBC) Monitor Operation: | |
|---|---|
| DTCs | P0263 – Cylinder #1 Contribution/Balance<br>P0266 – Cylinder #2 Contribution/Balance<br>P0269 – Cylinder #3 Contribution/Balance<br>P0272 – Cylinder #4 Contribution/Balance<br>P0275 – Cylinder #5 Contribution/Balance<br>P0278 – Cylinder #6 Contribution/Balance<br>P0281 – Cylinder #7 Contribution/Balance<br>P0284 – Cylinder #8 Contribution/Balance |
| Monitor Execution | continuous |
| Monitor Sequence | None |
| Sensors OK | CKP (P0335, P0336) |
| Typical Monitoring Duration | 10 sec |

| Typical Fuel Balancing Control (FBC) Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| P0263, P0266, P0269, P0272, P0275, P0278, P0281, P0284: | | |
| Engine speed | 500 rpm | 3000 rpm |
| Injection quantity | 3.5 mg/stroke | 90 mg/stroke |
| Not In Regeneration | | |
| FBC wheel learn complete | | |

| Typical Fuel Balancing Control (FBC) Monitor Malfunction Thresholds: |
|---|
| If the current correction for the injector exceeds 90% of the allowable correction for current operation conditions, the code is set. |

**Nominal Voltage Calibration:**

Nominal Voltage Calibration (NVC) is a series of closed-loop controllers on the charge/discharge profile of fuel injectors during an injection event. NVC is designed to compensate for changes due to aging of the piezo stack and hydraulic control elements within individual injectors and of the injector charging circuitry to maintain consistent operation of these components over the life of the injector. The injector charge/discharge profile is shown in the figure below.



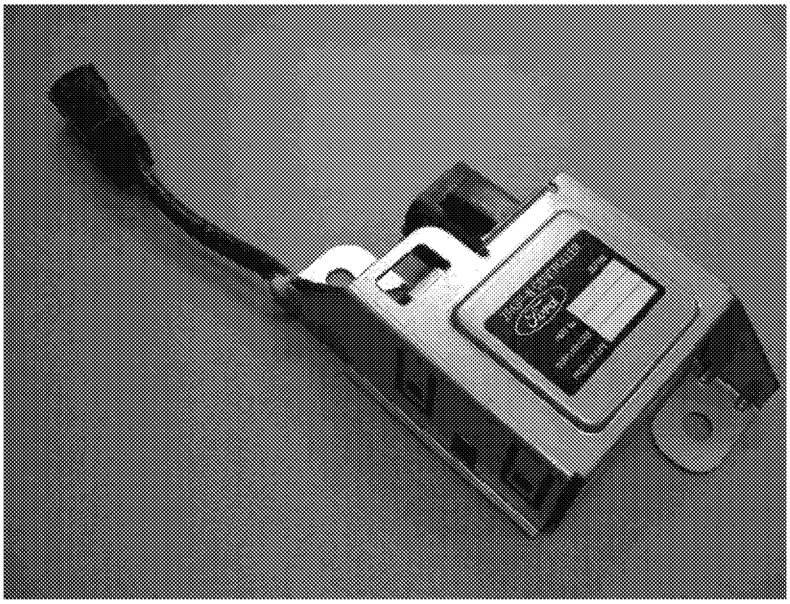

| Nominal Voltage Calibration (NVC) Monitor Operation: | |
|---|---|
| DTCs | P1551 – Cylinder 1 Injector Circuit Range/Performance<br>P1552 – Cylinder 2 Injector Circuit Range/Performance<br>P1553 – Cylinder 3 Injector Circuit Range/Performance<br>P1554 – Cylinder 4 Injector Circuit Range/Performance<br>P1555 – Cylinder 5 Injector Circuit Range/Performance<br>P1556 – Cylinder 6 Injector Circuit Range/Performance<br>P1557 – Cylinder 7 Injector Circuit Range/Performance<br>P1558 – Cylinder 8 Injector Circuit Range/Performance |
| Monitor Execution | continuous |
| Monitor Sequence | None |
| Sensors OK | Injector open circuit (P0201-0208), Injector performance (P02EE-02F5), Injector short circuit (P1201-1208), Injector high to low short (P1261-1268), ECT (P0117, P0118), RPS (P0191, P0192, P0193, P228E, P228F) |
| Typical Monitoring Duration | 2 sec (set point voltage), 90 sec (other two tests) |

| Typical Nominal Voltage Calibration (NVC) Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Rail pressure | 1200 bar | 1600 bar |
| Engine coolant temperature | 70 deg C | 100 deg C |
| Injection duration | 300 us | |
| Single pilot-main injection profile | | |

| Typical Nominal Voltage Calibration (NVC) Monitor Malfunction Thresholds: |
|---|
| If the set point voltage at end of energizing (yellow dot in figure) exceeds the allowable voltage given in the chart below for the current rail pressure set point or if there exists a persistent deviation between set and measured discharge time (yellow dot to blue dot in figure) or if there exists a persistent deviation between the set and measured voltage at end of energizing (yellow dot in figure) |

| Maximum Allowable Voltage At End of Energizing : | | | | |
|---|---|---|---|---|
| Rail pressure (bar) | 300 | 800 | 1200 | 2000 |
| Maximum allowed voltage (V) | 89 | 91 | 93 | 108 |

## Air-Fuel Ratio Sensors: Feedgas NOx Sensor Control Module



The NOx controller module is mounted to the vehicle frame under the body. It is used to control the feed gas NOx sensor mounted in diesel after-treatment exhaust system upstream of the SCR and DPF on a Chassis Certified Vehicle and upstream of the SCR only on a Dynamometer Certified Vehicle. It communicates to the ECU via HSCAN to report NOx concentrations or OBDII errors.

The controller module consists of RAM, ROM, EEPROM, Ip1 circuit, Ip2 circuit, Rpvs circuit, heater driver, microprocessor, and temperature sensor. The RAM temporarily stores information obtained from the sensing element during operation. The ROM and EEPROM store sensor and controller module calibration coefficients obtained during the manufacturing process. The Ip2 circuit adjusts the pumping current in the sensing element's Ip2 circuit for NOx detection. The Ip2 circuit consists of 2 bands: a wide range and a narrow range. The Rpvs circuit is a measurement of the resistance of the Vs cell of the sensor element. This measurement is used to estimate the temperature of the sensing element. The heater driver supplies a PWM voltage to the heater portion of the sensing element to maintain the element's target operational temperature. PID feedback from Rpvs is used to control and maintain the element temperature. The microprocessor processes all of the inputs from the sensing element and outputs to the CAN circuit. The temperature sensor in the controller module is used for compensating the temperature dependency of circuit components and for OBD rationality checks.

The NOx controller module interfaces with the vehicle via a power source, signal ground, power ground, CAN-H and CAN-L. The compensated NOx concentration; Rpvs, pressure compensation factors, sensor/module OBD (including monitor completion flags), module temperature, software ID, CALID, and CVN are communicated via HSCAN to the vehicle PCM.

| NOx Controller Module Malfunctions | |
|---|---|
| DTCs | P06EA NOx Sensor Processor Performance (Bank 1 Sensor 1)<br>U05A1 NOx Sensor "A" Received Invalid Data From ECM/PCM<br>P225A NOx Sensor Calibration Memory (Bank 1 Sensor 1) |
| Monitor execution | Continuous |
| Monitor Sequence | Ip2-N and Ip2-W range rationality – 50ppm < [NOx] < 100ppm |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical NOx Controller Malfunction Thresholds |
|---|
| P06EA RAM failure<br>ROM CRC check error<br>EEPROM CRC check error<br>Ip1 out of range – Ip1(VIP2.1) < 1.8V, Ip1(VIP2.1) > 2.2V, Ip1(VIP2.2) < 0.2V, or Ip1(VIP2.2) > 0.6V<br>Ip2-W out of range – Vs+ ≥ 5.35V and Ip2-W > 4.8V<br>Ip2-N out of range – Vs+ ≥ 5.35V and Ip2-N < 0.2V<br>Ip2-N and Ip2-W range rationality – Integral value of differential between Ip2-N & Ip2-W ≥ 250ppm<br>Vp2 circuit failure – Vp2 < 250mV or Vp2 > 650mV<br>Rpvs short to ground – Rpvs < 0.2V<br>Temperature sensor short to battery – Temp > 4.5V<br>Temperature sensor short to ground – Temp < 0.45V<br>Temperature sensor open – 0.45V ≤ Temp < 0.48V<br>NOx Module temperature within 40 deg. C of Exhaust Temperature Sensor on Cold Start |
| U05A1 Erroneous Signal (Dew point reached with ignition off, etc.)<br>Timeout (>1 second before message received) |
| P225A Memory does not pass CRC check |

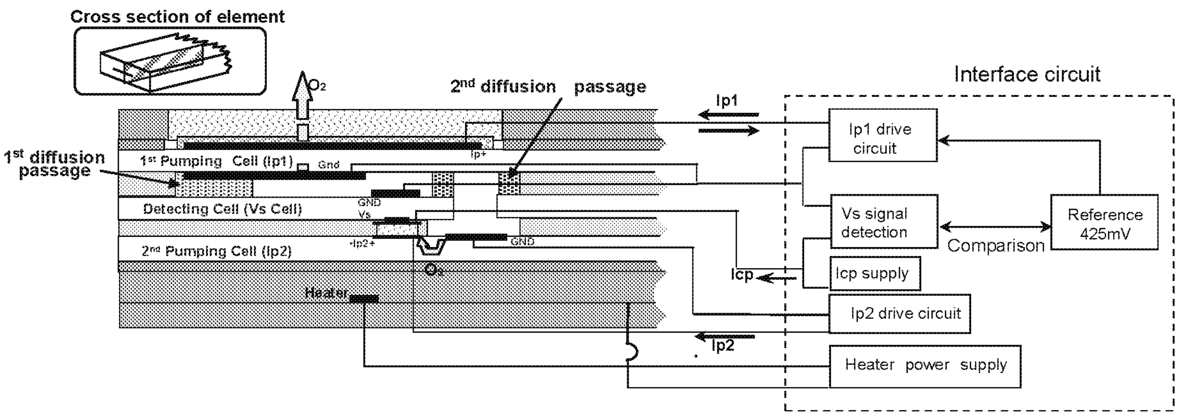
The NOx sensor is primarily used to sense NOx concentrations in diesel exhaust gas. The sensor is mounted in a vehicle's exhaust pipe, perpendicular to exhaust gas flow. The sensor is typically mounted, in an aftertreatment-equipped diesel exhaust system, upstream of the SCR and DPF on a Chassis Certified Vehicle and upstream of the SCR only on a Dynamometer Certified Vehicle. The sensor interfaces to a NOx controller module that controls the sensor element's sense circuit and heater.

The Ip2 (NOx concentration) measurement takes place in a 2nd measurement chamber. Exhaust gas passes from the 1st measurement chamber through a 2nd diffusion barrier into the 2nd measurement chamber. The NOx present in the 2nd measurement chamber is dissociated into N2 and O2. The excess O2 is pumped out of the 2nd measurement chamber by the pumping current, Ip2. Ip2 is proportional to the NOx concentration in the measured gas.

The NOx sensor is equipped with a memory component which stores unique sensor characteristics used to compensate for part-to-part variation of the element during the manufacturing process. The memory stores Ip1 and Ip2 gains/offsets for each individual sensor.

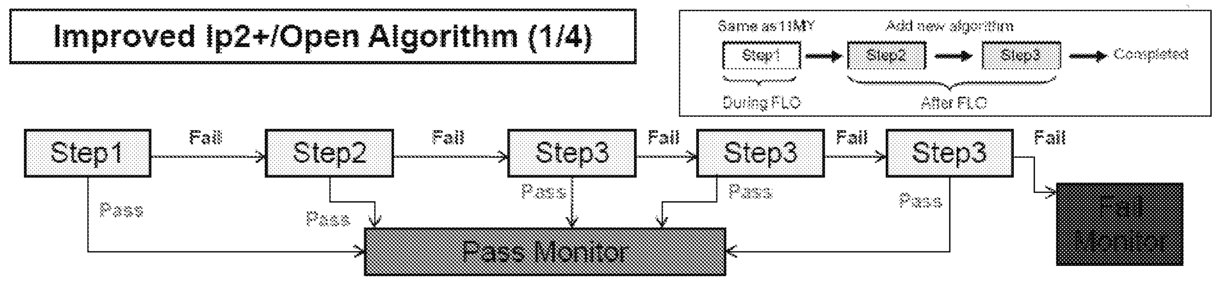
The NOx sensor interfaces the NOx controller module with the following:

**Ip2 – pumping current for pumping out dissociated O2 from 2nd chamber**
**COM – virtual ground for Vs, Ip1, and Ip2 circuits**
**Vs – Nernst cell voltage, 425mV from COM. Also carries current for pumped reference.**
**TM – Touch memory which stores Ip1 and Ip2 gain/offset.**
**TM GND – Ground for touch memory reading**
**H+ – Heater voltage (High-side driver) – Duty cycle ON/OFF to control sensor temperature.**
**H- – Heater ground side**



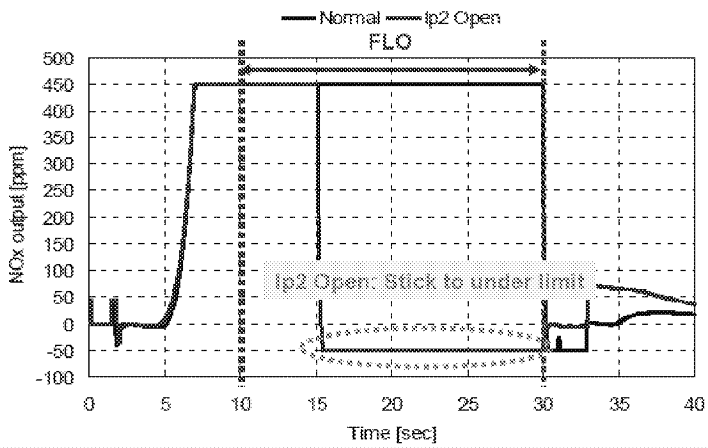
IP2 Open (FLO) OBD Algorithm

## Improved Ip2+/Open Algorithm (1/4)




Step1
(Current algorithm)

- This algorithm runs during FLO by using constant current circuit.
- If Ip2 open occurs, Ip2 voltage sticks on 0V.
- Ip2 voltage is at 5V in no failure.




IP2 Open (FLO) OBD Algorithm

## Improved Ip2+/Open Algorithm (2/4)

## Ip2+/Open After FLO(1/3)

**Two more steps are added for Ip2+/Open detection.**

**Step2 : Ip2+ wire NOT Open Judgment**

If Ip2+ wire is open, Ip2 current is stuck.

The other hands, if Ip2+ wire is not open, Ip2 current should flow by FLO control, or by the atmosphere.

**<OBD Active Condition>**
1sec passed after FLO

**<Judge Condition>**
If one of the following conditions is concluded at least, Ip2+ wire is judged normal.

A. $\frac{T_O}{1sec} \geq 5\%$ **(T.B.D.)** $T_O$ : The sum of the time when Ip2 is out of 5ppm window for 1sec.

B. $|Ip2N_{Max} - Ip2N_{Min}| \geq 6ppm$ ($\pm$3ppm) **(T.B.D.)**
$Ip2N_{Max}$ : Maximum of Ip2 current for 1sec
$Ip2N_{Min}$ : Minimum of Ip2 current for 1sec

| A | B | Judgment |
|---|---|---|
| False | False | Ip2+ wire may be disconnected. Diagnosis is to be continued step2. |
| False | True | **Ip2+ wire is no failure. Diagnosis is complete.** |
| True | False | |
| True | True | |

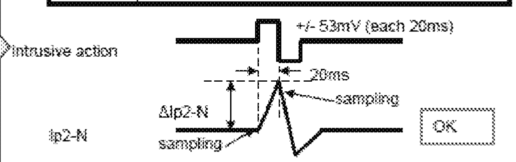
**Step3 : Ip2 Open Judgment**

Ip2+/Open is judged by swinging vp2 voltage in a moment.

This procedure is same as the algorithm of Ip2+/Open@F/C of 10MY.

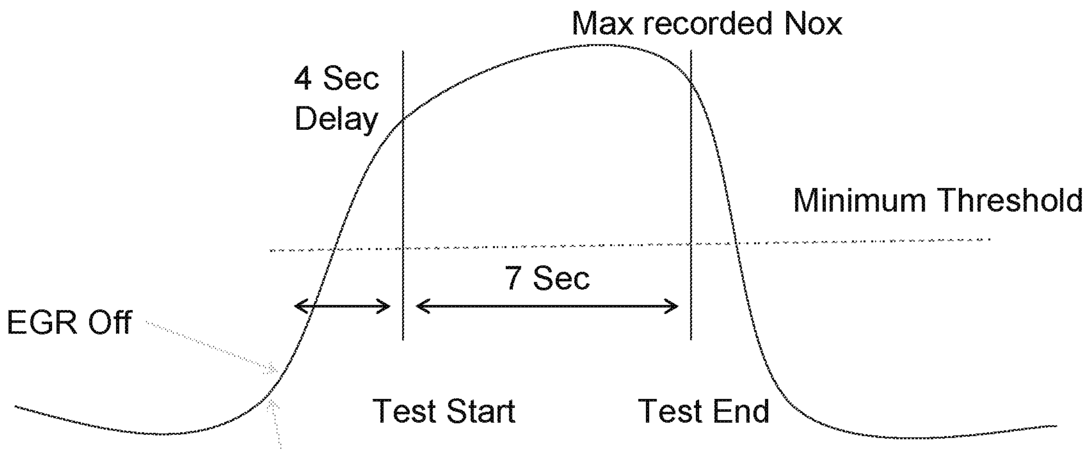
1. Sampling Ip2-N voltage.
2. Intrusive action (positive voltage)
3. Sampling Ip2-N voltage.
4. Intrusive action (negative voltage)
5. Judgment by ΔIp2-N

| ΔIp2-N | Judgment |
|---|---|
| < 1V | Ip2+ wire may be disconnected. **Restart from step1 until 3 times.** |
| ≥1V | **Ip2+ wire is no failure. Diagnosis is complete.** |




Diagnosis complete

The Feed Gas Low NOx Plausibility Monitor runs once per drive cycle during an intrusive EGR shutoff, in which the calculated NOx value (using fuel quantity, temperature and ambient pressure) is then compared to the threshold.




| FG NOx Plausibility Monitor | |
|---|---|
| DTCs | P2201 - NOx Sensor Circuit Range/Performance (Bank 1 Sensor 1) |
| Monitor execution | Once a drive cycle |
| Monitor Sequence | When EGR is disabled at idle, for air mass adaptation, the monitor runs. |
| Sensors OK | Nox Sensor, EGR system |
| Monitoring Duration | 11 seconds to register a malfunction |

| Typical Nominal FG Nox Plausibility Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Pedal Position | | 0% |
| Fuel | 7 mg/stroke | 15 mg/stroke |
| Engine Coolant | 70C | |
| Fuel Cut Duration before test | 1.5 sec. | |

| Typical NOx Controller Malfunction Thresholds |
|---|
| Measured maximum nox is less than 50% of expected. |

| NOx Sensor Malfunctions | |
|---|---|
| DTCs | P2200 NOx Sensor Circuit (Bank 1 Sensor 1)<br>P2201 NOx Sensor Circuit Range/Performance (Bank 1 Sensor 1)<br>P220E NOx Sensor Heater Control Circuit Range/Performance (Bank 1 Sensor 1)<br>P2209 NOx Sensor Heater Sense Circuit Range/Performance (Bank 1 Sensor 1)<br>P220A NOx Sensor Supply Voltage Circuit (Bank 1 Sensor 1) |
| Monitor execution | continuous |
| Monitor Sequence | Ip2 Open – O2 ≥ 5% or F/C > 3 seconds and O2 ≥ 19%<br>Ip2 Crack – F/C > 5 seconds and O2 ≥ 19% |
| Sensors OK | not applicable |

**Typical NOx Sensor Malfunctions Thresholds**

P2200 Vs, COM, Ip1 short to battery – ASIC Diag2=1 and Vs, COM, Ip1 ≥ 9V
Ip2 short to battery – Ip2 ≥ 4.8V
Vs, COM, Ip1 short to ground – ASIC Diag2=1 and Vs, COM, Ip1 < 9V
Ip2 short to ground – Ip2 ≤ 2V
Ip1 Open – Vs ≤ 225mV, Vs ≥ 625mV & -0.2mA ≤ Ip1 ≤ 0.2mA
Vs Open – Vs > 1.5V
COM Open – Rpvs > RpvsA (target Rpvs stored in sensor memory) or ASIC Diag1=1
Ip2 Open – Ip2-W ≤ 0.2V and Ip2-N ≤ 0.2V
Sensor Memory CRC check
Vs/Ip1 Cell Crack – Ip1 > 6.4mA
Ip2 Cell Crack – Ip2-W > 4.8V

P2201 NOx Sensor reading 50% Lower than expected (low threshold) during EGR Off
NOx Negative Offset – Nox Sensor greater than ~ - 20 ppm offset
NOx Positive Offset – Nox Sensor greater than ~50 ppm offset

P220E Heater control failure – Rpvs ≥ 0.2V and Rpvs < TRpvs - 30Ω or Rpvs > TRpvs + 30Ω
Heater Open – Heater current < 0.4A
Heater short to battery – Δ Heater Voltage > 0.2V
Heater short to ground – Δ Heater Voltage > 0.2V
Heater performance failure – Heater current ≥ 0.4A and Heater Resistance ≥ 11Ω

P2209 NOx Availability – > 1 PL (Healing mode) per cycle or > 9 sec of NOx not valid

P220A Battery failure – Battery > 17V or Battery < 10V

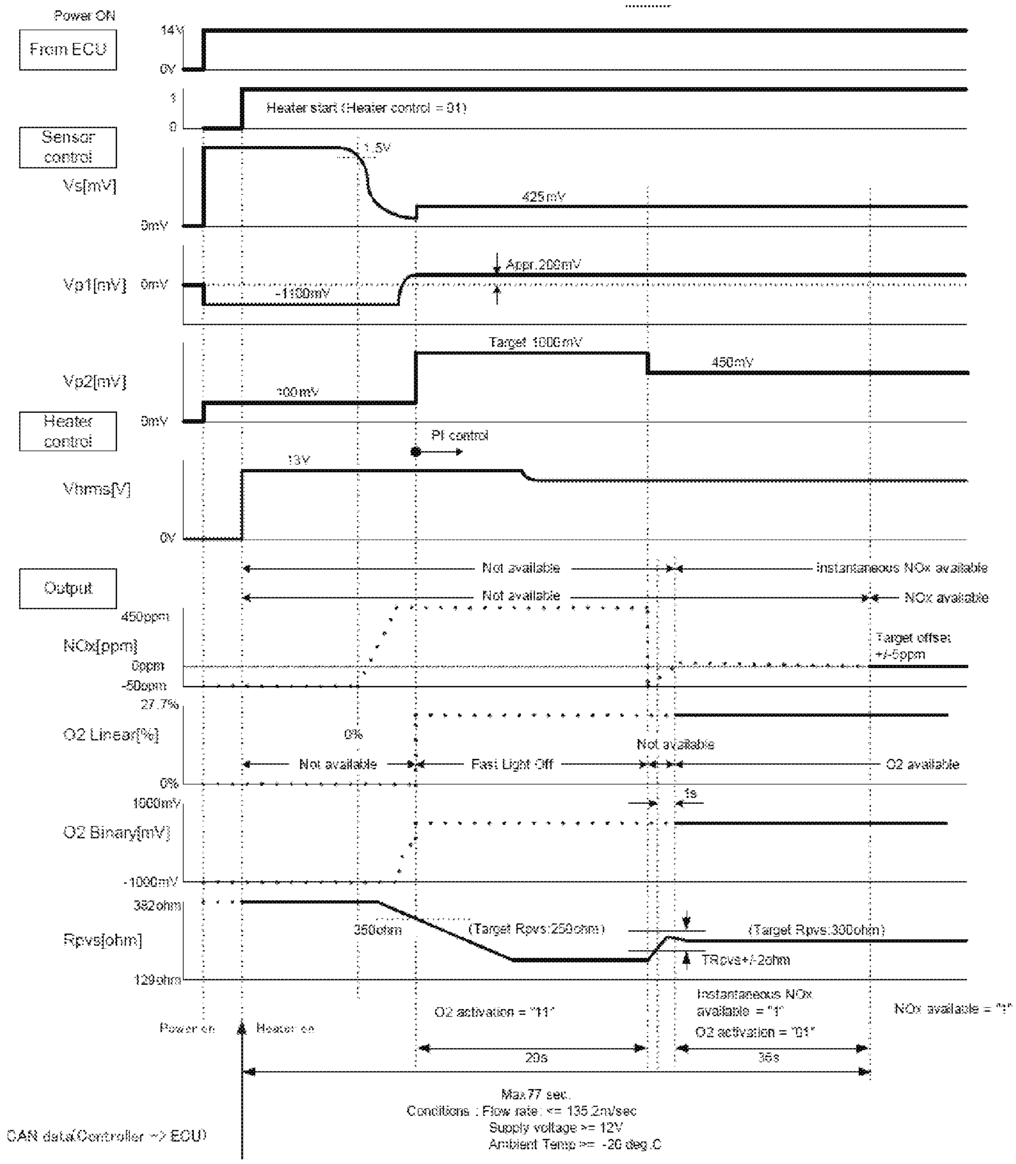
NOx Sensor Operation Modes

Drive start — Drive end

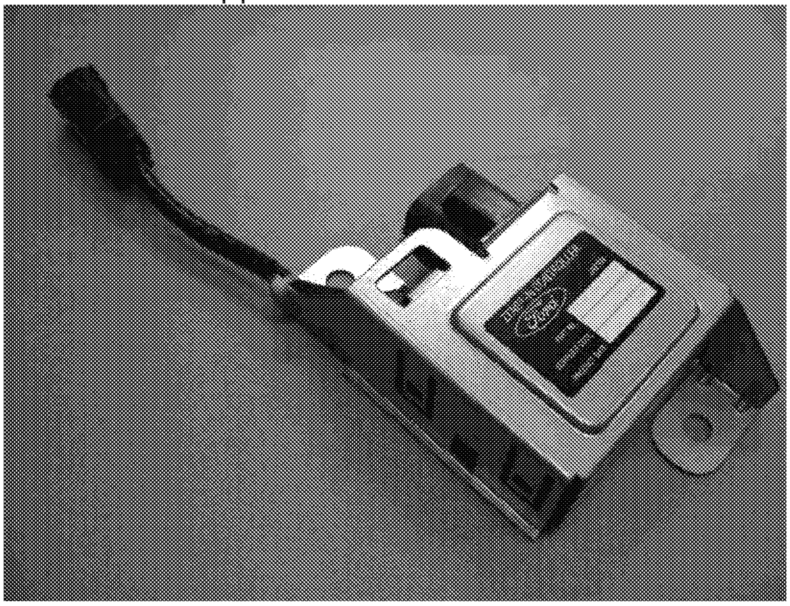
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Engine OFF | Engine OFF | Engine ON | | | | | | Engine OFF | Engine OFF |
| Key-OFF | Key-ON | Key-ON | | | | | | Key OFF | Key-OFF |
| - | - | Heater OFF | NA Mode Vs No Active | NA Mode Vs Active | A Mode under FLO | A Mode After FLO | A Mode & F/C | Self Shut Down | - |
| ① | ②:In case of normal<br>⑨:In case of engine stall | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ | ⑩ | ① |

Failure occurred timing

Mode 1 – No voltage supply to module or sensor. Non-operational.
Mode 2 – Voltage is supplied to module, yet voltage is not supplied to the sensor.
Mode 3 – Voltage is supplied to module, yet voltage is not supplied to the sensor. Dew-point waiting period.
Mode 4 – Voltage is supplied to the module and to the sensor. The Vs cell of the sensor is not active.
Mode 5 – Voltage is supplied to the module and to the sensor. The Vs cell of the sensor is active.
Mode 6 – Voltage is supplied to the module and to the sensor. Sensor is in fast light-off to quickly heat sensing element to operational temperature.
Mode 7 – Voltage is supplied to the module and to the sensor. The sensor has exited fast light-off and O2 and NOx will be available during this mode.
Mode 8 - Voltage is supplied to the module and to the sensor. The sensor has exited fast light-off and O2 and NOx will be available during this mode. During this mode a fuel cut condition is present, as communicated by the PCM.
Mode 9 - Voltage is supplied to module, yet voltage is not supplied to the sensor.
Mode 10 - No voltage supply to module or sensor. Non-operational.



Air-Fuel Ratio Sensors: Tailpipe NOx and O2 Sensor Control Module



The NOx controller module is mounted to the vehicle frame under the body. It is used to control the combination tailpipe NOx and O2 sensor mounted in diesel after-treatment exhaust system downstream of the SCR and DPF. It communicates to the ECU via HSCAN to report NOx and O2 concentrations or OBDII errors.

The controller module consists of RAM, ROM, EEPROM, Ip1 circuit, Ip2 circuit, Rpvs circuit, heater driver, microprocessor, and temperature sensor. The RAM temporarily stores information obtained from the sensing element during operation. The ROM and EEPROM store sensor and controller module calibration coefficients obtained during the manufacturing process. The Ip1 circuit consists of an ASIC (like that of a UEGO ASIC) that adjusts pumping current in the sensing element's Ip1 circuit for O2 detection. The Ip2 circuit adjusts the pumping current in the sensing element's Ip2 circuit for NOx detection. The Ip2 circuit consists of 2 bands: a wide range and a narrow range. The Rpvs circuit is a measurement of the resistance of the Vs cell of the sensor element. This measurement is used to estimate the temperature of the sensing element. The heater driver supplies a PWM voltage to the heater portion of the sensing element to maintain the element's target operational temperature. PID feedback from Rpvs is used to control and maintain the element temperature. The microprocessor processes all of the inputs from the sensing element and outputs to the CAN circuit. The temperature sensor in the controller module is used for compensating the temperature dependency of circuit components and for OBD rationality checks.

The NOx controller module interfaces with the vehicle via a power source, signal ground, power ground, CAN-H and CAN-L. The compensated O2 concentration compensated NOx concentration; Rpvs, pressure compensation factors, sensor/module OBD (including monitor completion flags), module temperature, software ID, CALID, and CVN are communicated via HSCAN to the vehicle PCM.

| NOx Controller Module Malfunctions | |
|---|---|
| DTCs | P06EB NOx Sensor Processor Performance (Bank 1 Sensor 2)<br>U05A2 NOx Sensor "B" Received Invalid Data From ECM/PCM<br>P225B NOx Sensor Calibration Memory (Bank 1 Sensor 2) |
| Monitor execution | Continuous |
| Monitor Sequence | Ip2-N and Ip2-W range rationality – 50ppm < [NOx] < 100ppm |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical NOx Controller Malfunction Thresholds |
|---|
| P06EB RAM failure<br>ROM CRC check error<br>EEPROM CRC check error<br>Ip1 out of range – Ip1(VIP2.1) < 1.8V, Ip1(VIP2.1) > 2.2V, Ip1(VIP2.2) < 0.2V, or Ip1(VIP2.2) > 0.6V<br>Ip2-W out of range – Vs+ ≥ 5.35V and Ip2-W > 4.8V<br>Ip2-N out of range – Vs+ ≥ 5.35V and Ip2-N < 0.2V<br>Ip2-N and Ip2-W range rationality – Integral value of differential between Ip2-N & Ip2-W ≥ 250ppm<br>Vp2 circuit failure – Vp2 < 250mV or Vp2 > 650mV<br>Rpvs short to ground – Rpvs < 0.2V<br>Temperature sensor short to battery – Temp > 4.5V<br>Temperature sensor short to ground – Temp < 0.45V<br>Temperature sensor open – 0.45V ≤ Temp < 0.48V<br>NOx Module temperature within 40 deg. C of Exhaust Temperature Sensor on Cold Start |
| U05A2 Erroneous Signal (Dew point reached with ignition off, etc.)<br>Timeout (>1 second before message received) |
| P225B Memory does not pass CRC check |

The NOx sensor is primarily used to sense O2 and NOx concentrations in diesel exhaust gas. The sensor is mounted in a vehicle's tailpipe, perpendicular to exhaust gas flow. The sensor is typically mounted downstream of an SCR and DPF in an aftertreatment-equipped diesel exhaust system. The sensor interfaces to a NOx controller module that controls the sensor element's sense circuit and heater.

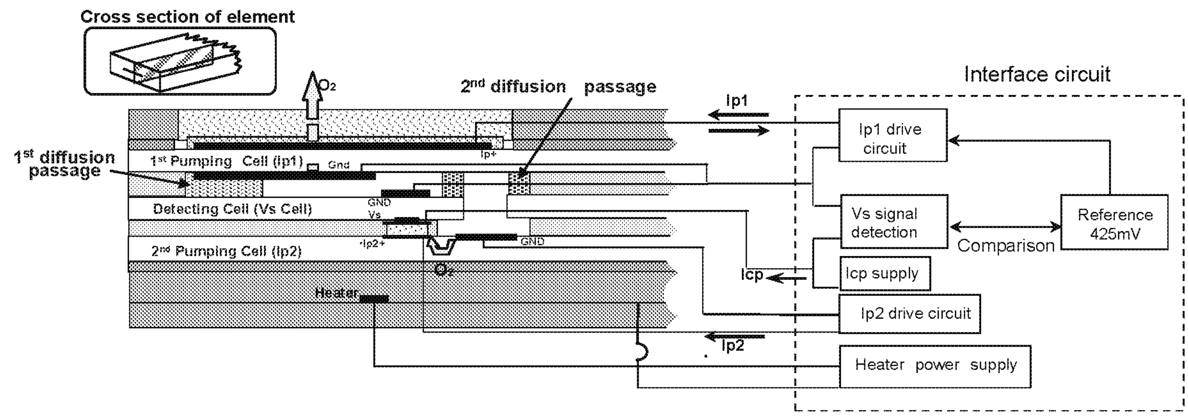
The NOx Sensor operates similarly to a UEGO sensor for measuring Ip1 (O2 concentration). Exhaust gas enters through a diffusion barrier into the 1st measurement chamber. The sensor infers an air fuel ratio relative to the stoichiometric (chemically balanced) air fuel ratio by balancing the amount of oxygen pumped in or out of the 1st measurement chamber. As the exhaust gasses get richer or leaner, the amount of oxygen that must be pumped in or out to maintain a stoichiometric air fuel ratio in the 1$^{st}$ measurement chamber varies in proportion to the air fuel ratio. By measuring the current required to pump the oxygen in or out, the O2 concentration can be estimated.

The Ip2 (NOx concentration) measurement takes place in a 2$^{nd}$ measurement chamber. Exhaust gas passes from the 1$^{st}$ measurement chamber through a 2$^{nd}$ diffusion barrier into the 2$^{nd}$ measurement chamber. The NOx present in the 2$^{nd}$ measurement chamber is dissociated into N2 and O2. The excess O2 is pumped out of the 2$^{nd}$ measurement chamber by the pumping current, Ip2. Ip2 is proportional to the NOx concentration in the measured gas.

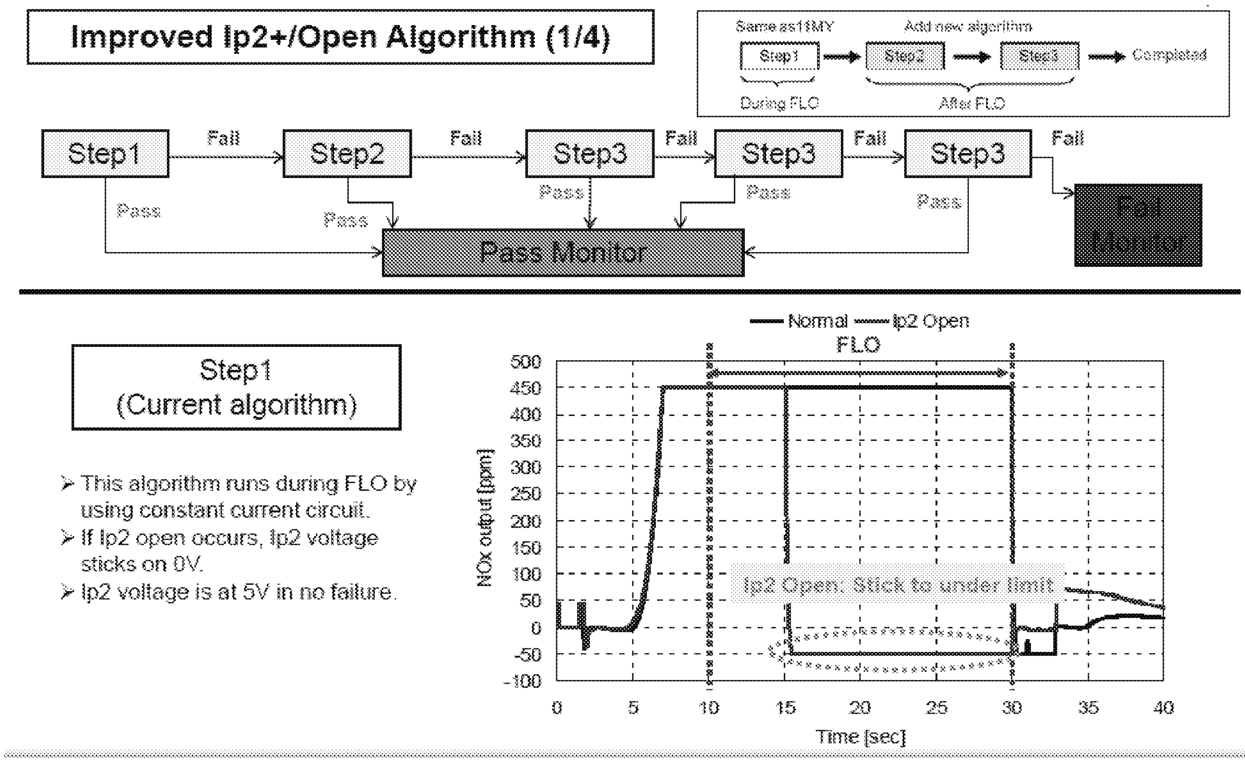
The NOx sensor is equipped with a memory component which stores unique sensor characteristics used to compensate for part-to-part variation of the element during the manufacturing process. The memory stores Ip1 and Ip2 gains/offsets for each individual sensor.

The NOx sensor interfaces the NOx controller module with the following:

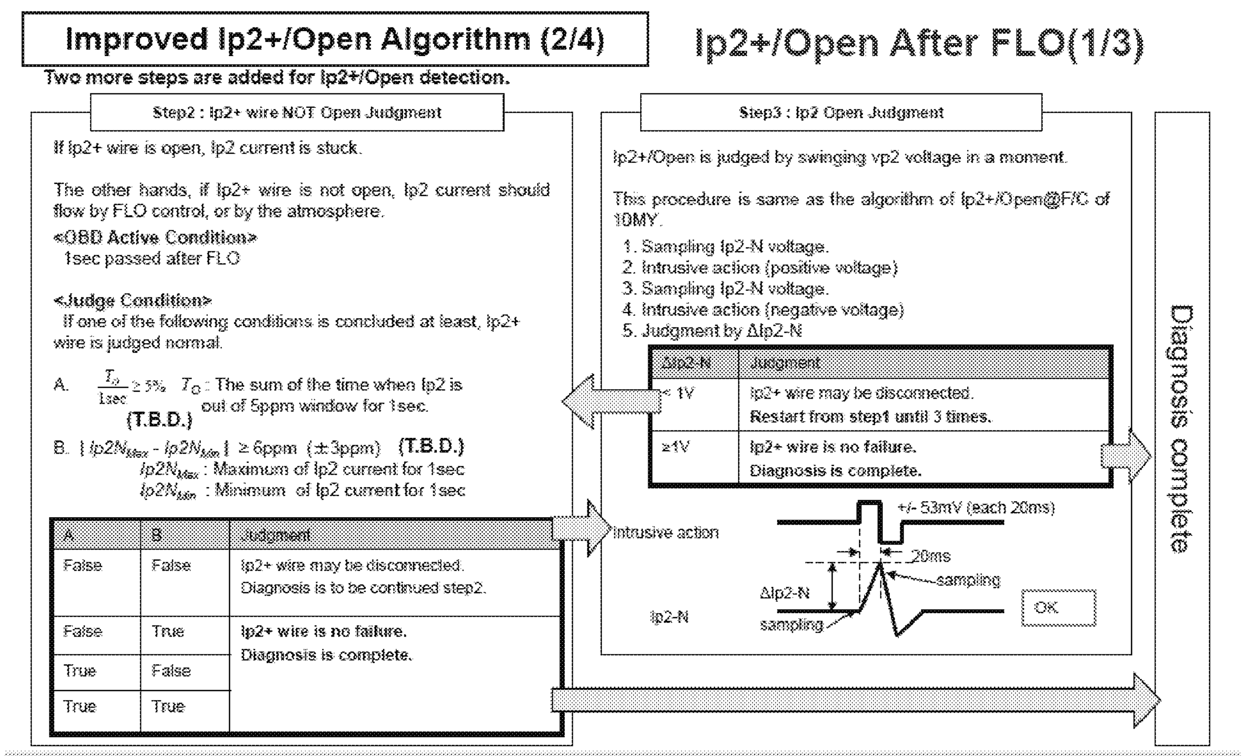
**Ip1 – pumping current for maintaining the A/F ratio in the 1$^{st}$ chamber**
**Ip2 – pumping current for pumping out dissociated O2 from 2$^{nd}$ chamber**
**COM – virtual ground for Vs, Ip1, and Ip2 circuits**
**Vs – Nernst cell voltage, 425mV from COM. Also carries current for pumped reference.**
**TM – Touch memory which stores Ip1 and Ip2 gain/offset.**
**TM GND – Ground for touch memory reading**
**H+ – Heater voltage (High-side driver) – Duty cycle ON/OFF to control sensor temperature.**
**H- – Heater ground side**



IP2 Open (FLO) OBD Algorithm




IP2 Open (FLO) OBD Algorithm

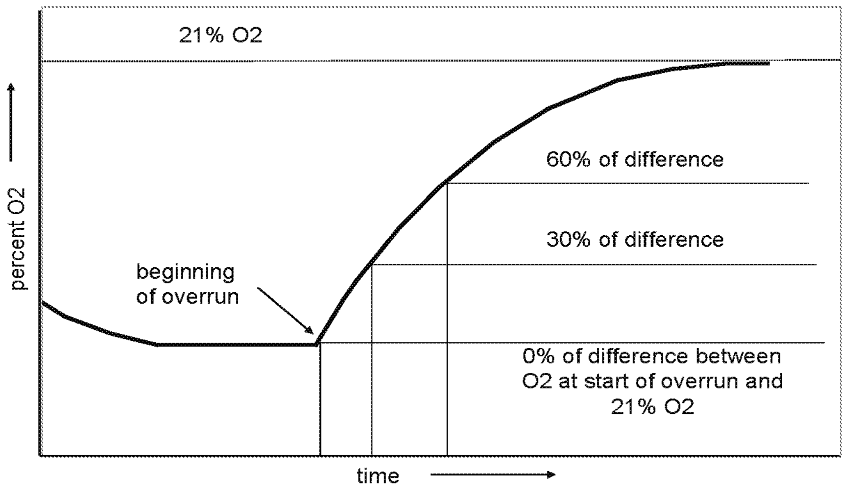


| NOx – O2 Sensor Malfunctions | |
|---|---|
| DTCs | P0139 O2 Sensor Circuit Slow Response (Bank 1 Sensor 2)<br>P0140 O2 Sensor Circuit No Activity Detected (Bank 1 Sensor 2)<br>P2A01 O2 Sensor Circuit Range/Performance (Bank 1 Sensor 2)<br>P229E NOx Sensor Circuit (Bank 1 Sensor 2)<br>P229F NOx Sensor Circuit Range/Performance (Bank 1 Sensor 2)<br>P220F NOx Sensor Heater Control Circuit Range/Performance (Bank 1 Sensor 2)<br>P22A7 NOx Sensor Heater Sense Circuit Range/Performance (Bank 1 Sensor 2)<br>P220B NOx Sensor Supply Voltage Circuit (Bank 1 Sensor 2) |
| Monitor execution | Continuous |
| Monitor Sequence | Ip2 Open – 02 ≥ 5% or F/C > 3 seconds and O2 ≥ 19%<br>Ip2 Crack – F/C > 5 seconds and O2 ≥ 19% |
| Sensors OK | not applicable |

| Typical NOx – O2 Sensor Malfunctions Thresholds |
|---|
| P0139 As shown in figure below, during a transition from load to overrun/decel fuel shutoff, one of the following occurs:<br>The time for the observed O2 percentage to increase from the value under load by 30% of (21%-O2 percentage under load) exceeds 6 seconds<br>OR<br>The time for the observed O2 percentage to increase from the value under load + 30% of the difference to the value under load + 60% of the difference exceeds 5 seconds<br>OR<br>The time for the observed O2 percentage to increase from the value under load to the value under load + 60% of the difference exceeds 11 seconds. (Used to detect completely inert sensors.)<br><br>(monitor operates when the vehicle is not undergoing particulate filter regeneration)<br><br>P0140 If there is no available O2 signal at 300 seconds after the sensor has achieved operating temperature<br><br>P2A01 A calculated oxygen concentration is derived from fuel, boost, and EGR. Observed oxygen concentration is evaluated within two speed/load/air mass ranges. Code is set if observed oxygen concentration falls outside the range ((calculated O2 concentration – negative offset, calculated O2 concentration + positive offset). Ranges and allowable O2 concentration deviations are given in the table below.<br>OR<br>In an extended overrun/decel fuel shutoff condition, an adaption factor is calculated for the response of the O2 sensor to ensure that the sensor reads 20.95% O2 in air. Code is set if adaption factor is outside the range 0.95 – 1.22.<br><br>(monitor operates when the vehicle is not undergoing particulate filter regeneration)<br><br>P229E Vs, COM, Ip1 short to battery – ASIC Diag2=1 and Vs, COM, Ip1 ≥ 9V<br>Ip2 short to battery – Ip2 ≥ 4.8V<br>Vs, COM, Ip1 short to ground – ASIC Diag2=1 and Vs, COM, Ip1 < 9V<br>Ip2 short to ground – Ip2 ≤ 2V<br>Ip1 Open – Vs ≤ 225mV, Vs ≥ 625mV & -0.2mA ≤ Ip1 ≤ 0.2mA |

| | |
|---|---|
| | Vs Open – Vs > 1.5V<br>COM Open – Rpvs > RpvsA (target Rpvs stored in sensor memory) or ASIC Diag1=1<br>Ip2 Open – Ip2-W ≤ 0.2V and Ip2-N ≤ 0.2V<br>Sensor Memory CRC check<br>Vs/Ip1 Cell Crack – Ip1 > 6.4mA<br>Ip2 Cell Crack – Ip2-W > 4.8V |
| P229F | NOx Negative Offset – Nox Sensor greater than ~ - 10 ppm offset<br>NOx Positive Offset – Nox Sensor greater than ~20 ppm offset<br>Tip-in – Filtered tailpipe Nox on tip-in delta > 0 ppm |
| P220F | Heater control failure – Rpvs ≥ 0.2V and Rpvs < TRpvs - 30Ω or Rpvs > TRpvs + 30Ω<br>Heater Open – Heater current < 0.4A<br>Heater short to battery – Δ Heater Voltage > 0.2V<br>Heater short to ground – Δ Heater Voltage > 0.2V<br>Heater performance failure – Heater current ≥ 0.4A and Heater Resistance ≥ 11Ω |
| P22A7 | NOx/O2 Availability – > 1 PL (Healing mode) per cycle or > 9 sec of Nox/O2 not valid |
| P220B | Battery failure – Battery > 17V or Battery < 10V |

P0133 (O2 slow response) monitor operation




**Oxygen Sensor Plausibility Measurement (P2A01) Evaluation Ranges and Allowable Deviations:**

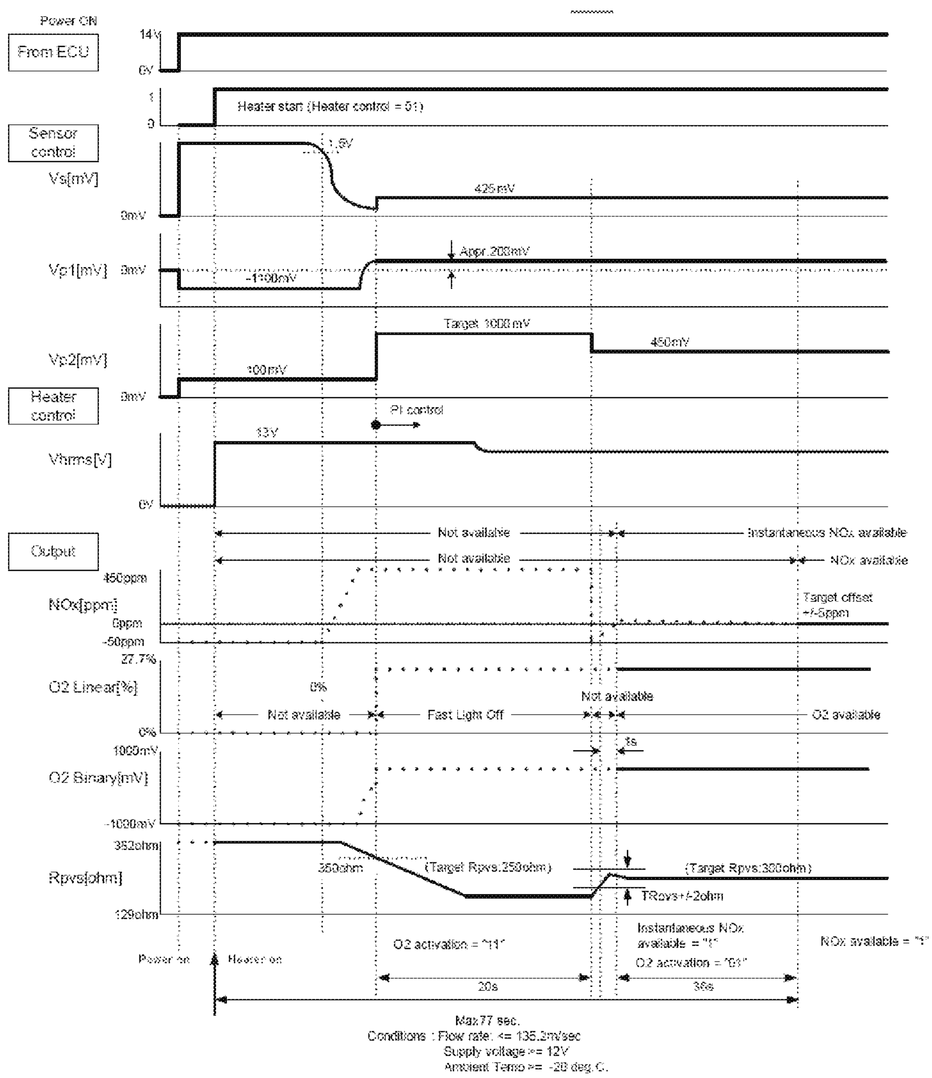
| | Range 1 | | Overrun | |
|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum |
| Engine speed (rpm) | 1100 | 2700 | 100 | 4000 |
| Fuel injection quantity (mg/stroke) | 15 | 38 | 0 | 0.5 |
| Air mass (mg/stroke) | 400 | 1000 | 100 | 1000 |
| Allowable deviation (% O2) | -7.0 | 5.5 | -5.0 | 4.6 |

## NOx Sensor Operation Modes

Drive start — Drive end

| Engine OFF | Engine OFF | Engine ON | | | | | | Engine OFF | Engine OFF |
|---|---|---|---|---|---|---|---|---|---|
| Key-OFF | Key-ON | Key-ON | | | | | | Key OFF | Key-OFF |
| - | - | Heater OFF | NA Mode Vs No Active | NA Mode Vs Active | A Mode under FLO | A Mode After FLO | A Mode & F/C | Self Shut Down | - |
| | Failure occurred timing | | | | | | | | |
| ① | ②:In case of normal<br>⑨:In case of engine stall | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ | ⑩ | ① |

Mode 1 – No voltage supply to module or sensor. Non-operational.
Mode 2 – Voltage is supplied to module, yet voltage is not supplied to the sensor.
Mode 3 – Voltage is supplied to module, yet voltage is not supplied to the sensor. Dew-point waiting period.
Mode 4 – Voltage is supplied to the module and to the sensor. The Vs cell of the sensor is not active.
Mode 5 – Voltage is supplied to the module and to the sensor. The Vs cell of the sensor is active.
Mode 6 – Voltage is supplied to the module and to the sensor. Sensor is in fast light-off to quickly heat sensing element to operational temperature.
Mode 7 – Voltage is supplied to the module and to the sensor. The sensor has exited fast light-off and O2 and NOx will be available during this mode.
Mode 8 - Voltage is supplied to the module and to the sensor. The sensor has exited fast light-off and O2 and NOx will be available during this mode. During this mode a fuel cut condition is present, as communicated by the PCM.
Mode 9 - Voltage is supplied to module, yet voltage is not supplied to the sensor.
Mode 10 - No voltage supply to module or sensor. Non-operational.



# EXHAUST GAS RECIRCULATION (EGR) SYSTEM MONITOR

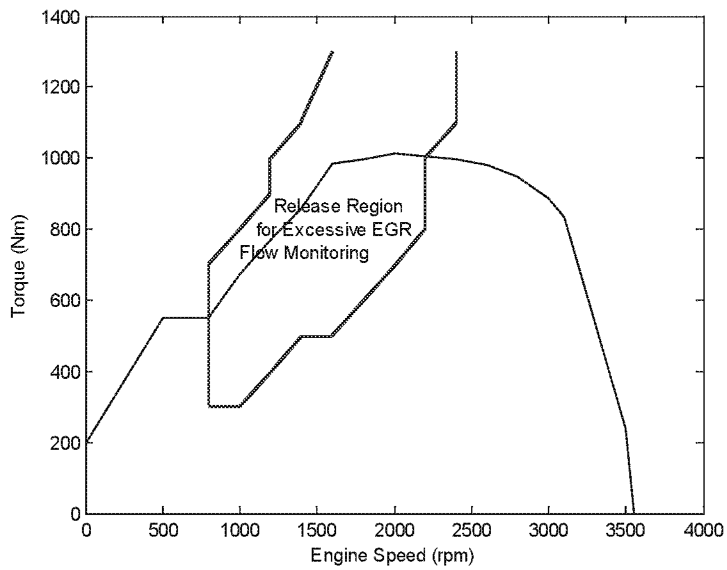
## EGR Rate System Monitor

The EGR system is a closed loop control system that controls percent of EGR in the cylinder using the EGR valve and Throttle. The percent of EGR is calculated using two different methods and the difference between these two calculations is used to determine if the system is operating corrected. First, the expected amount of EGR in the cylinder is calculated using a model that is based on the commanded EGR and Throttle position. Second, the EGR in the cylinder is measured by subtracting the mass air sensor (MAF) reading from a speed-density model of the air charge into the cylinder. The speed-density model accounts for both fresh air and EGR and is based on the volumetric efficiency of the engine. High or excessive EGR flow is detected when the measured amount of EGR is greater than the expected amount of EGR. Low or insufficient EGR flow is detected when the measured amount of EGR is less than the expected amount of EGR. A slow EGR system is detected using the excessive EGR flow system monitor.

The monitor compares the two calculations, when a set of entry conditions are met, and determines if the system is operating correctly. The entry conditions are selected to ensure robust fault/non-fault detection. A summary of the entry conditions is shown in the tables below. The fault must be detected for a minimum amount of time before being reported. A timer counts up when the entry conditions are met and the fault is present. The timer counts down when the entry conditions are met, the fault is not present, and the current count is greater than 0. When this timer exceeds the time required detect a malfunction, the malfunction is reported.

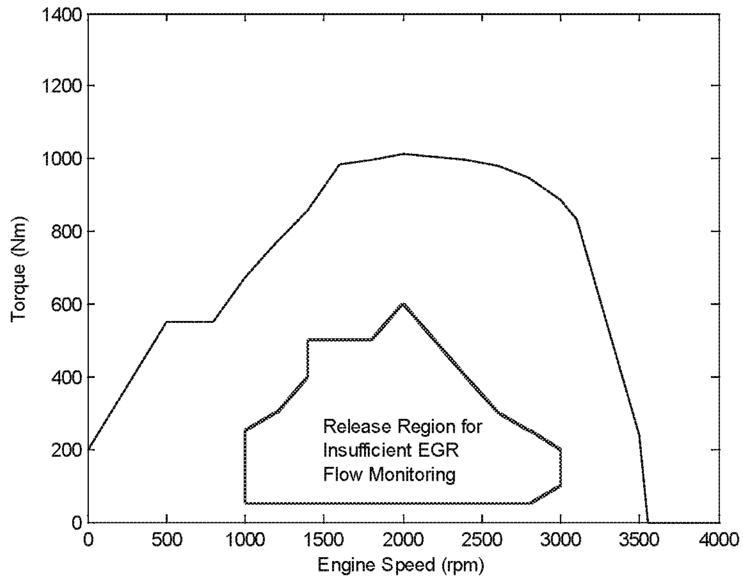
| EGR Flow Check Operation: | |
|---|---|
| DTCs | P0401 – Insufficient EGR Flow<br>P0402 – Excessive EGR Flow |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration High Flow | 4 seconds required to detect a malfunction |
| Monitoring Duration Low Flow | 8 seconds required to detect a malfunction |

| Typical EGR Flow Check Entry Conditions (High Flow Detection): | | |
|---|---|---|
| **Entry Condition** | **Minimum** | **Maximum** |
| Engine Torque | Monitor is released in a speed/load region as shown in the following figure. | |
| Engine RPM | | |
| Engine Coolant Temperature | 70 deg C | 100 deg C |
| EGR Valve Position | 0% | 6% |
| Desired EGR Ratio | 0% | 15% |
| Ambient Pressure | 74.5 kPa | |
| EGR System in Closed Loop Control | | |




| Typical EGR High Flow Rate Malfunction Thresholds: |
|---|
| Expected EGR Ratio – Measured EGR Ratio < -15 (function of engine speed / torque) |

| Typical EGR Flow Check Entry Conditions (Low Flow Detection): | | |
|---|---|---|
| **Entry Condition** | **Minimum** | **Maximum** |
| Engine Torque | Monitor is released in a speed/load region as shown in the following figure. | |
| Engine RPM | | |
| Engine Coolant Temperature | 70 deg C | 100 deg C |
| EGR Valve Position | 40% | 60% |
| Desired EGR Ratio | 0% | 100% |
| Ambient Pressure | 74.5 kPa | |
| EGR System in Closed Loop Control | | |

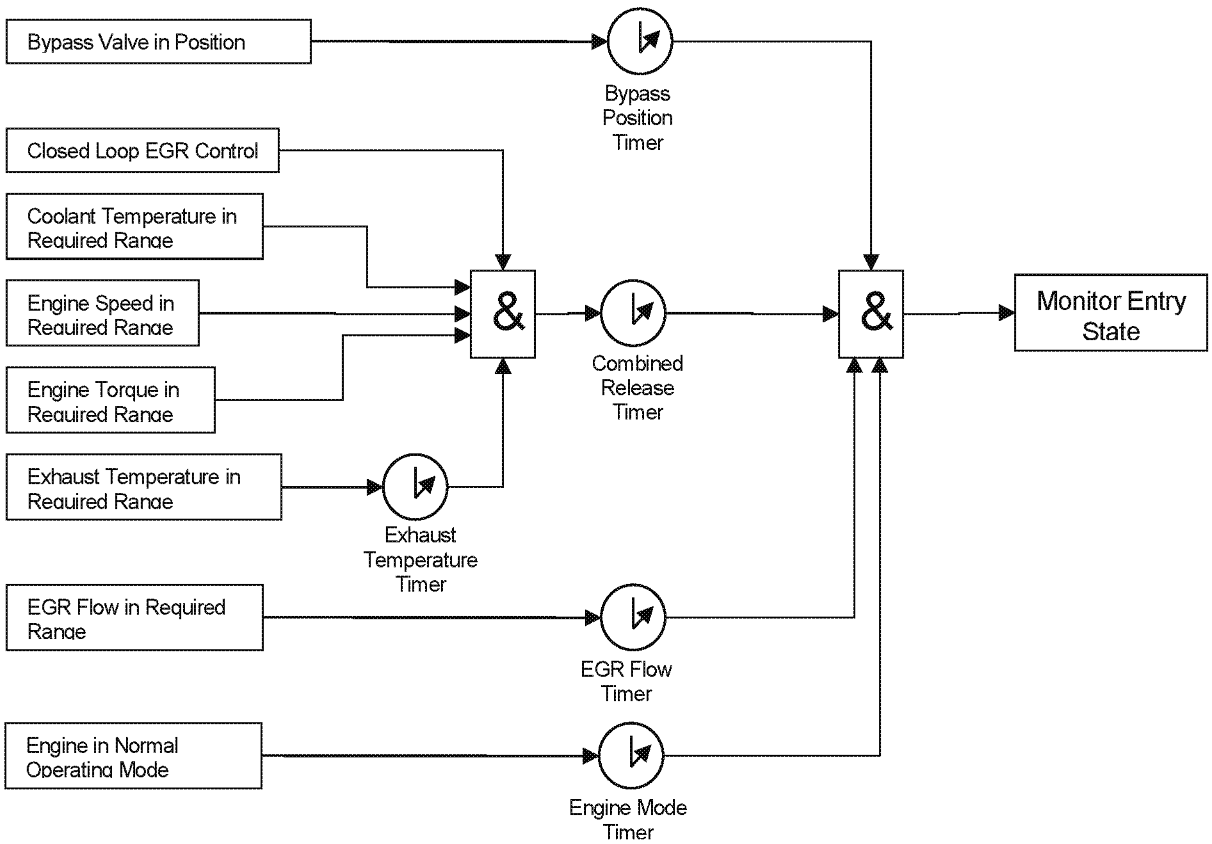



| Typical EGR Low Flow Rate Malfunction Thresholds: |
|---|
| Expected EGR Ratio – Measured EGR Ratio > 10 (function of engine speed / torque) |

## EGR Cooler / EGR Cooler Bypass Monitor

The following describes the method of monitoring the EGR cooling system on chassis certified applications. A second monitoring method is used on dynamometer certified applications and is described later in this section. The functionality of the EGR cooler system, including the bypass valve and temperature sensor, is monitored by means of comparing measured EGR gas temperature downstream of the EGR cooler assembly with measured coolant temperature in the main coolant loop when certain engine operating conditions exist. The operating conditions in which this detection can occur are the monitor entry conditions. Following changes in engine operating conditions, there is a delay before the changes are reflected in the EGR system temperatures. Because of this delay the entry conditions include a number of timers which must complete before the monitor is released. When a condition feeding a timer is no longer met, the timer resets. Two malfunction conditions, EGR overcooling and EGR undercooling can be detected using the EGR cooler monitors.

Monitor Entry Condition Timer Locations




The undercooling monitor can detect when EGR is not being cooled sufficiently, for example, when the EGR cooler bypass is stuck in the bypass position. The entry conditions for EGR undercooling monitoring must be met for monitoring to take place. Once the entry conditions are met and while they continue to be met, the measured EGR temperature downstream of the EGR cooler assembly is compared to a threshold which is determined based on measured coolant temperature. A typical value for this threshold is 70 deg C above engine coolant temperature. If the measured EGR temperature downstream of the EGR cooler assembly is greater than the threshold, for a predetermined amount of time, a fault is detected.

| EGR Cooler (Undercooling) Monitor: | |
|---|---|
| DTCs | P2457 – EGR Cooler Performance |
| Monitor execution | Once per driving cycle , once entry conditions are met |
| Monitor Sequence | None |
| Monitoring Duration | 12 seconds to detected a malfunction |

| EGR Cooler/ECB Entry Conditions (Undercooling): | | |
|---|---|---|
| **Entry Condition** | **Minimum** | **Maximum** |
| EGR Cooler Bypass Valve Command | Cooling Position | |
| EGR System in Closed-Loop Control | | |
| Engine Coolant Temperature | 70 deg C | 130 deg C |
| Engine Speed | 1100 rpm | 3500 rpm |
| Engine Torque | 200 Nm | 1400 Nm |
| Exhaust Temperature | 0 deg C | 800 deg C |
| EGR Flow | 0 g/s | 42 g/s |
| Engine Operating Mode | Normal | |

| EGR Cooler/ECB Entry Timers (Undercooling): | |
|---|---|
| **Timer** | **Minimum Time** |
| Bypass Position Timer | 5 sec |
| Combined Release Timer | 1 sec |
| Exhaust Temperature Timer | 5 sec |
| EGR Flow Timer | 5 sec |
| Engine Mode Timer | 100 sec |

| Typical Undercooling Malfunction Thresholds: |
|---|
| Measured EGR temperature downstream of the EGR cooler assembly > Coolant Temperature + 70 |

The overcooling monitor can detect when EGR is being overcooled, for example, when the EGR cooler bypass is stuck in the cooling position. The entry conditions for EGR overcooling monitoring must be met for monitoring to take place. Once the entry conditions are met and while they continue to be met, the measured EGR temperature downstream of the EGR cooler assembly is compared to a threshold which is determined based on measured coolant temperature. A typical value for this threshold is 16 deg C below engine coolant temperature. If the measured EGR temperature downstream of the EGR cooler assembly is less than the threshold, for a predetermined amount of time, a fault is detected.

| EGR Cooler (Overcooling) Monitor: | |
|---|---|
| DTCs | P24A5 – Exhaust Gas Recirculation Cooler Bypass Control Stuck (Bank 1) |
| Monitor execution | Once per driving cycle , once entry conditions are met |
| Monitor Sequence | None |
| Monitoring Duration | 12 seconds to detected a malfunction |

| EGR Cooler/ECB Entry Conditions (Overcooling): | | |
|---|---|---|
| **Entry Condition** | **Minimum** | **Maximum** |
| EGR Cooler Bypass Valve Command | Cooling Position | |
| EGR System in Closed-Loop Control | | |
| Engine Coolant Temperature | 70 deg C | 130 deg C |
| Engine Speed | 575 rpm | 900 rpm |
| Engine Torque | 70 Nm | 300 Nm |
| Exhaust Temperature | 0 deg C | 800 deg C |
| EGR Flow | 6 g/s | 42 g/s |
| Engine Operating Mode | Normal | |

| EGR Cooler/ECB Entry Timers (Overcooling): | |
|---|---|
| **Timer** | **Minimum Time** |
| Bypass Position Timer | 5 sec |
| Combined Release Timer | 5 sec |
| Exhaust Temperature Timer | 5 sec |
| EGR Flow Timer | 5 sec |
| Engine Mode Timer | 100 sec |

| Typical Overcooling Malfunction Thresholds: |
|---|
| Measured EGR temperature downstream of the EGR cooler assembly < Coolant Temperature -16 |

On dynamometer certified applications, the EGR cooling system is monitored by intrusively moving the bypass door from the cooling position to the bypass position and looking at the response of the temperature out of the EGR cooler. The gradient (slope) of the temperature is compared to a threshold, if the gradient is less than the threshold for the entire monitoring duration, a fault is detected. In contrast, on a non-fault system, once the gradient exceeds the threshold, the monitor pass is latched. Once the monitor pass is latched, the bypass door returns to the cooling position to protect the engine hardware from overheating. Even though, the bypass door returns to the cooling position before the monitor is complete but the monitor continues to be released as long as the entry conditions are met. The monitor only completes once the monitor is released for the full monitoring duration, consecutively.

Monitoring is done during somewhat steady state operation at medium to high speed-load conditions with sufficient EGR flow. Entry are selected so the monitor is released to run when the conditions are correct. The entry conditions required to release the monitor are listed EGR Cooler (Intrusive) Entry Conditions table below. The bypass door must be in the cooling position for a minimum calibrated time for the monitor to be released. The rest of the entry conditions must be met for a different minimum calibrated time before the monitor is released.

To protect the hardware, the monitor is not allowed to re-release immediately if the release is lost because one of more of the entry condition are no longer met.

| EGR Cooler (Intrusive) Monitor: | |
|---|---|
| DTCs | P245A – Exhaust Gas Recirculation (EGT) Cooler Bypass Control Circuit (bank 1) |
| Monitor execution | Once per driving cycle , once entry conditions are met |
| Monitor Sequence | None |
| Monitoring Duration | 3 seconds to detected a malfunction |

| EGR Cooler (Intrusive) Entry Conditions: | | |
|---|---|---|
| **Entry Condition** | **Minimum** | **Maximum** |
| EGR Cooler Bypass Valve Command (only evaluated during monitor pre-release) | Cooling Position | |
| EGR System in Closed-Loop Control | | |
| Engine Coolant Temperature | 70 deg C | 140 deg C |
| Engine Speed | 575 rpm | 900 rpm |
| Filtered Absolute Value of the Gradient of Engine Speed | | 150 rpm/s |
| Engine Torque | 70 Nm | 300 Nm |
| Filtered Absolute Value of the Gradient of Engine Torque | | 150 Nm/s |
| Exhaust Temperature | 300 deg C | 700 deg C |
| Filtered Absolute Value of the Gradient of Exhaust Temperature | | 8 deg C / s |
| Fuel Injection Quantity | 0.1 g/rev | 0.4 g/rev |
| Filtered Absolute Value of the Gradient of Fuel Injection Quantity | | 0.05 g/rev/s |
| EGR Flow | 22 g/s | 112 g/s |
| Filtered Absolute Value of the Gradient of EGR Flow | | 22 g/s/s |
| Modeled Intake Manifold Temperature | | 140 deg C |
| Engine Operating Mode | Normal | |

| Typical Malfunction Thresholds: |
|---|
| Measured Gradient of EGR Downstream Temperature < 8 deg C / s |

## EGR System Slow Response

Slow responding EGR systems are detected through the EGR rate system monitor.

## EGR Control Limits Monitor

The control limit monitor functions continuously during normal (non-regen) closed-loop operation. The control limits monitor compares the desired percent of EGR with the measured percent of EGR. If the error between these is greater than the threshold for the required duration of time, a fault is set. Specifically, a timer counts up when the entry conditions are met and the fault is present. The timer counts down when the entry conditions are met, the fault is not present, and the current count is greater than 0. When this timer exceeds the time required detect a malfunction, the malfunction is reported.

| EGR Closed-loop Control Limits Check Operation: | |
|---|---|
| DTCs | P04DA (Closed Loop EGR Control At Limit - Flow Too High)<br>P04D9 (Closed Loop EGR Control At Limit - Flow Too Low) |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 20 seconds to detect a malfunction |

| Typical EGR Closed-loop Control Limits Check Entry Conditions: |
|---|
| No Air System Faults |
| EGR system in closed loop EGR control |

| Typical EGR Control Limits Malfunction Thresholds: |
|---|
| Desired EGR Ratio – Measured EGR Ratio < -60 (function of Engine Speed / Torque)<br>or<br>Desired EGR Ratio – Measured EGR Ratio > 45 (function of Engine Speed / Torque) |

### Mass Airflow Closed-loop Control Limits Monitor

During DPF regeneration the engine control system controls the mass of fresh air into the cylinder using the EGR valve and throttle valve. In this operating mode, the desired mass of fresh air in the cylinder is compared to the actual mass of air entering the cylinder. If the error is greater than the threshold for the required duration, a fault is set. The monitor is released when the system is in closed loop control. Specifically, a timer counts up when the entry conditions are met and the fault is present. The timer counts down when the entry conditions are met, the fault is not present, and the current count is greater than 0. When this timer exceeds the time required detect a malfunction, the malfunction is reported.

| Mass Airflow Closed-loop Control Limits Check Operation: | |
|---|---|
| DTCs | P02EC - Diesel Intake Air Flow Control System - High Air Flow Detected<br>P02ED - Diesel Intake Air Flow Control System - Low Air Flow Detected |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 20 seconds required to detect a malfunction |

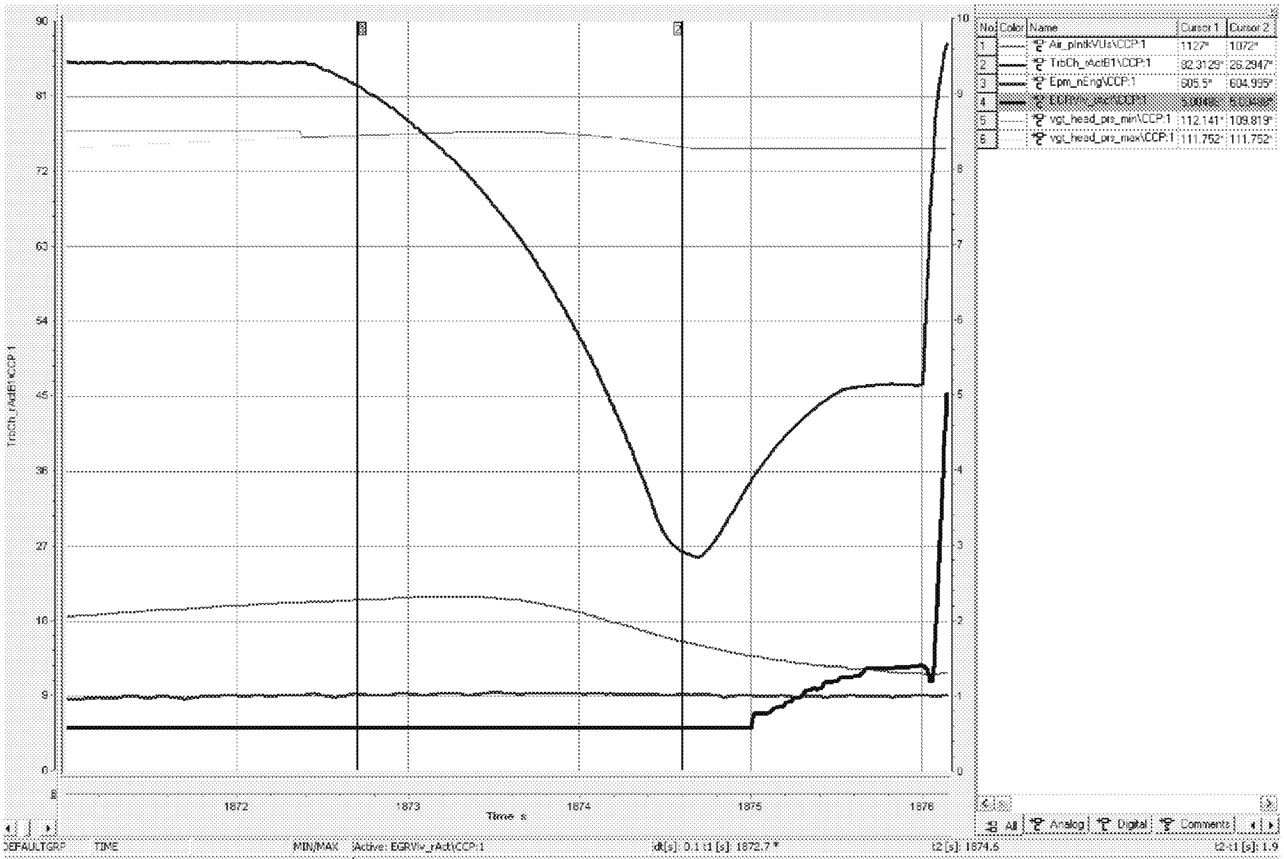
| Typical Mass Air Flow Closed-loop Control Limits Check Entry Conditions: |
|---|
| No Air System Faults |
| EGR System in closed loop air mass control |

| Typical Air Mass Control Limits Malfunction Thresholds: |
|---|
| Desired Air Mass – Measure Air Mass > 400 (function of Engine Speed / Torque)<br>or<br>Desired Air Mass – Measure Air Mass < -400 (function of Engine Speed / Torque) |

## BOOST PRESSURE CONTROL SYSTEM MONITORING

### Intrusive Turbo Position and Response Monitoring

The 6.7L engine is equipped with an oil pressure actuated, variable vane turbocharger. Additionally, chassis cert applications have a wastegate for bypassing exhaust gas to assist with controlling boost while in heavy load situations. Neither the variable geometry turbo (VGT) nor the wastegate have position sensors, so turbo and wastegate position is inferred using a duty cycle to position transfer function. To verify actual position based on the nominal transfer function, an intrusive monitor sweep is performed. When entry conditions are met, the intrusive monitor for VGT closes the EGR valve, closes the wastegate, and then commands an inferred turbo position of 85%, then 25% within a calibratable time. The minimum and maximum MAP values are saved and compared to a threshold. If the desired separation in MAP pressure isn't achieved, a fault is detected. If the desired separation in MAP is achieved, the test is considered a pass.




In the example above, at 1871 seconds, the EGR valve is commanded closed, after 3 seconds with EGR off and turbocharger at 85% position, the turbocharger is opened up to. 25% position. The 25% position is held for 4 seconds. If desired separation of 2kpa at sea level is achieved the test is considered a pass. If desired separation isn't achieved the test is completed and failed.

Note: this monitor also serves to monitor for a slowly responding boost pressure system due to the time component of the threshold.

| VGT Monitor: | |
|---|---|
| DTCs | P132B - Turbocharger/Supercharger Boost Control "A" Performance |
| Monitor Execution | Once per driving cycle |
| Monitor Sequence | VGT, then wastegate |
| Sensors OK | ECT, MAP, VS |
| Typical Monitoring Duration | 7 seconds for full VGT monitoring cycle if pressure abort threshold hasn't been reached |

| Typical VGT Monitor Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine speed for learning | 500 rpm | 760 rpm |
| Pedal position allowed for learning | | 0.5 % |
| Engine coolant temperature for learning | 70 deg C | 124 deg C |
| Fuel quantity allowed for learning | | 20 mg/stoke |
| Vehicle speed for learning | | 3 mph |
| Loop counts after brake cycle | | 800 counts |
| Barometric Pressure | 67 kPa | 102 kPa |
| Time after engine start | 120 seconds | |

| Typical VGT Monitor Malfunction Thresholds: |
|---|
| Response from 25% VGT position to 85% VGT position in 4 seconds results in a change in manifold pressure of 2 kPa or greater at sea level or 1.25 kPa at 8000 feet. |

## Intrusive Wastegate Monitoring

The intrusive wastegate monitor operates on the same principles and has the same entry conditions as the intrusive VGT monitor. It runs once the VGT monitor completes, using the same commanded VGT position (85%) and an EGR valve position up to 10%). The wastegate is commanded to 5% open for 2 seconds, then 95% open for 2 seconds. The minimum and maximum EBP values are saved and compared to a threshold. If the desired separation in EBP pressure isn't achieved, a fault is detected.

| Wastegate Monitor: | |
|---|---|
| DTCs | P1249- Wastegate Control Valve Performance |
| Monitor Execution | Once per driving cycle |
| Monitor Sequence | VGT, then wastegate |
| Sensors OK | ECT, MAP, VS |
| Typical Monitoring Duration | 4 seconds for full wastegate monitoring |

| Typical Wastegate Monitor Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine speed for learning | 500 rpm | 760 rpm |
| Pedal position allowed for learning | | 0.5 % |
| Engine coolant temperature for learning | 70 deg C | 124 deg C |
| Fuel quantity allowed for learning | | 20 mg/stoke |
| Vehicle speed for learning | | 3 mph |
| Loop counts after brake cycle | | 800 counts |
| Barometric Pressure | 67 kPa | 102 kPa |
| Time since start | 120 seconds | |

| Typical Wastegate Monitor Malfunction Thresholds: |
|---|
| Response from 5% wastegate position to 95% wastegate position in 2 seconds results in a change in exhaust backpressure of 2.0 kPa or greater at sea level or 1.25 kPa at 8000 feet. |

## Functional Overboost Monitoring

The 6.7L engine utilizes a closed loop boost pressure controller to maintain desired boost pressure set point under all temperature ranges and engine operating modes. The overboost monitor compares the desired vs. actual measured boost pressure while in a specific range of closed loop boost pressure operation. If the boost pressure governor deviation is greater than the calibrated threshold for 7 seconds, a fault is detected and the P-code is set. The closed loop monitoring window is defined as any inner torque above 50 nm, and any engine speed above 1000 rpm. Torque window and threshold slightly different for dyno cert due to different turbocharger configuration, calibration, and air path response.

This diagnostic will detect a turbo slowly responding or stuck in the primarily closed condition.

| Overboost Monitor: | |
|---|---|
| DTCs | P0234 - Turbocharger/Supercharger "A" Overboost Condition |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ECT, MAP, MAF, |
| Typical Monitoring Duration | 7 seconds for fault detection |

| Typical Overboost Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Torque | 50 Nm | |
| Engine Speed | 1000 | 4000 |

| Typical Overboost Monitor Malfunction Thresholds: |
|---|
| If desired boost pressure – actual boost pressure < -15.0 kPa for 7 seconds, a fault is detected. |

## Functional Underboost Monitoring

The underboost monitor works in a similar fashion to the overboost monitor by comparing the desired vs. actual measured boost pressure while in a specific range of closed loop boost pressure operation. If the boost pressure governor deviation is greater than the calibrated threshold for 7 seconds, a fault is detected and the P-code is set. The closed loop monitoring window is defined as any inner torque above 50 nm, and any engine speed above 1500 rpm. The threshold limit is wider for the underbooost monitor due to transient boost system response, compensation for boost pressure lag, and short term (1-2 second) momentary torque truncation when air path torque is kept high, but fueling is limited for component protection.

This diagnostic will detect a gross air path leak such as the turbo discharge or CAC discharge tube being blown off, major pre-turbo exhaust leaks, or a turbo slowly responding or stuck in the open VGT position.

| Overboost Monitor: | |
|---|---|
| DTCs | P1247 - Turbocharger Boost Pressure Low |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ECT, MAP, MAF, |
| Typical Monitoring Duration | 7 sec |

| Typical Overboost Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Torque | 50 Nm | |
| Engine Speed | 1000 rpm | 4000 rpm |

| Typical Overboost Monitor Malfunction Thresholds: |
|---|
| If desired boost pressure – actual boost pressure > 15 kPa for 7 seconds, a fault is detected. |

## Threshold Underboost Monitoring

The pressure-based underboost diagnostic is adequate for detecting gross air system leaks; however, the emissions threshold leak to exceed the HC standard is approximately a one quarter inch NPT hole. With a leak of that magnitude, the closed loop boost pressure governor is capable of maintaining the desired boost pressure. The functional underboost monitor is not able to detect a leak of such size, so an additional boost system diagnostic is utilized since desired pressure is maintained in the system.

The closed loop boost pressure controller controls boost based predicted control targets and anticipated turbocharger position. The output value, in percentage, indicates the "control effort" required to maintain the desired boost pressure. With a boost system leak, the control effort increases. There is a temperature entry condition, torque entry conditions, a steady state requirement on manifold pressure, an exhaust temperature entry condition, an exhaust lambda entry condition, and a threshold map. If the threshold is exceeded for 4 seconds, a fault is detected. This diagnostic will also detect a turbocharger VGT mechanism stuck in the open position.

| Threshold Underboost Monitor: | |
|---|---|
| DTCs | P0299 - Turbocharger/Supercharger "A" Underboost Condition |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ECT, MAP, MAF |
| Typical Monitoring Duration | 7 sec |

| Threshold Underboost Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Torque | 200 Nm | 700 Nm |
| Engine coolant temperature | -7 deg C | |
| Ambient air temperature | -7 deg C | |
| Barometric Pressure | 75 kPa | 110 kPa |
| MAP steady state pressure | | 100 kPa |
| TOxiCatUs Temperature | 99 deg C | |
| Mass Air Flow | | 1300 kg/h |
| Not in Cold Start Warm-up Mode | | |
| Regeneration Status | None | |

| Typical Threshold Underboost Monitor Malfunction Thresholds: |
|---|
| If control effort percent is > threshold map for 4 seconds and Exhaust Lambda is less than 1.33, a fault is detected. |

| Typical Threshold Underboost monitor (P0299) Threshold Map | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RPM/TRQ** | **600** | **750** | **1000** | **1200** | **1600** | **2000** | **2250** | **2500** | **2750** | **3000** | **3250** | **3500** |
| **0** | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| **100** | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| **150** | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| **200** | 50 | 50 | 20 | 12 | 12 | 12 | 12 | 12 | 12 | 25.5 | 25.5 | 25.5 |
| **250** | 50 | 50 | 20 | 12 | 12 | 12 | 12 | 12 | 12 | 27.5 | 27.5 | 25.5 |
| **300** | 50 | 50 | 20 | 12 | 12 | 12 | 12 | 12 | 12 | 27.5 | 27.5 | 25.5 |
| **350** | 50 | 50 | 20 | 12 | 12 | 12 | 12 | 12 | 12 | 27.5 | 27.5 | 25.5 |
| **400** | 50 | 50 | 20 | 12 | 12 | 12 | 12 | 15 | 15 | 25.5 | 25.5 | 25.5 |
| **450** | 50 | 50 | 20 | 12 | 12 | 12 | 12 | 15 | 16 | 25.5 | 25.5 | 25.5 |
| **500** | 50 | 50 | 20 | 12 | 12 | 12 | 12 | 18.5 | 18.5 | 25.5 | 25.5 | 25.5 |
| **600** | 50 | 50 | 20 | 12 | 12 | 12 | 12 | 18.5 | 22.5 | 25.5 | 25.5 | 25.5 |
| **700** | 50 | 50 | 20 | 12 | 12 | 12 | 12 | 18.5 | 22.5 | 25.5 | 25.5 | 25.5 |

## Threshold Overboost Monitoring

The pressure-based overboost diagnostic is adequate for detecting a turbo stuck in the closed position on the dyno cert application, however with a stuck turbocharger on the chassis cert application the pressure deviation is not significant because of wastegate operation. With a wastegate in place, the closed loop boost pressure governor is capable of maintaining the desired boost pressure with the turbocharger stuck in a closed position. The functional overboost monitor is not able to detect this, so an additional boost system diagnostic is utilized since desired pressure is maintained in the system.

The closed loop boost pressure controller controls boost based predicted control targets and anticipated turbocharger position. The output value, in percentage, indicates the "control effort" required to maintain the desired boost pressure. With a turbocharger stuck in the closed position, the control effort decreases. There is a temperature entry condition, torque entry conditions, a steady state requirement on manifold pressure, an exhaust temperature entry condition, and a threshold map. If the threshold is exceeded for 4 seconds, a fault is detected.

| Threshold Overboost Monitor: | |
|---|---|
| DTCs | P0234 - Turbocharger/Supercharger "A" Overboost Condition |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ECT, MAP, MAF |
| Typical Monitoring Duration | 4 sec |

| Typical Threshold Overboost Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Torque | 200 Nm | 700 Nm |
| Engine coolant temperature | -7 deg C | |
| Ambient air temperature | -7 deg C | |
| Barometric Pressure | 75 kPa | 110 kPa |
| MAP steady state pressure | | 100 kPa |
| TOxiCatUs Temperature | 99 deg C | |
| Mass Air Flow | | 1300 kg/h |
| Not in Cold Start Warm-up Mode | | |
| Regeneration Status | None | |

| Typical Threshold Overboost Monitor Malfunction Thresholds: |
|---|
| If control effort percent is < threshold map for 4 seconds a fault is detected. |

| Typical Threshold Overboost monitor (P0234) Threshold Map | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RPM/TRQ** | **600** | **750** | **1000** | **1200** | **1600** | **2000** | **2250** | **2500** | **2750** | **3000** | **3250** | **3500** |
| **0** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **100** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **150** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **200** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **250** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **300** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **350** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **400** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **450** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **500** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **600** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |
| **700** | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 | -43 |

## Charge Air Cooler Monitoring

The 6.7L engine is equipped with an air to water charge air intercooler. The CAC is on a secondary coolant loop, independent from the main engine coolant system. The temperature at the outlet of the cooler is measured as TCACDs, however the temperature going into the cooler is modeled.

To detect a CAC under cooling situation, the efficiency of the cooler is modeled at various speeds and airflows via a 3d speed/airflow multiplier table, providing a modeled cooler out temperature. Cooler efficiency * compressor out temperature = modeled cooler out temp. This modeled cooler out temp is then compared to the measured coolant out temp, if the difference is less than a threshold curve or greater than a threshold, a fault is detected and a p-code is set.

| Charge Air Cooler Monitor: | |
|---|---|
| DTCs | P026A - Charge Air Cooler Efficiency Below Threshold<br>P007E - Charge Air Cooler Temperature Sensor Intermittent/Erratic (Bank 1) |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ECT, MAP, MAF |
| Typical Monitoring Duration | 4 seconds for fault detection |

| Typical Charge Air Cooler Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine speed | 1100 rpm | 3350 rpm |
| Engine coolant temperature | 70 deg C | |
| Ambient air temperature | -7 deg C | |
| Barometric Pressure | 74.5 kPa | 110 kPa |
| Manifold absolute pressure | 120 kPa | |
| Intake air temperature | -7 deg C | |
| Injection quantity | 20mg/stk | 85mg/stk |

| Typical Charge Air Cooler Monitor Malfunction Thresholds: |
|---|
| P026A - If the difference of measured temperature and modeled temperature is less than -15 deg C at 0 deg C compressor out temp, or less than -10 deg C at 250 deg C compressor out temp, a fault is set.<br>P007E – If the difference of measured temperature and modeled temperature is greater than 35 deg C a fault is set. |

# PARTICULATE MATTER (PM) FILTER MONITORING

## DPF Filter Efficiency Monitor

The DPF is monitored to ensure no leaks have developed in the substrate. The monitor runs after a regeneration event where sufficient time was spent above a temperature threshold (in order to insure a proper regen). The DPF Filter Efficiency monitor compares the calculated restriction (from a sensor measuring delta pressure across the DPF) to the expected restriction calculated from a soot model (using various engine sensors as inputs). After a successful regeneration event, the monitor waits for DPF temperatures to fall below a threshold (400 degC, to allow for an accurate soot estimate)and for a small quantity of soot to build up in the DPF (approx 3 grams). At this point, the monitor performs a filtering routine on the calculated restriction (from deltaP sensor) and locks in the initial restriction. Once sufficient soot has built up in the DPF (based on integrated soot from the soot model), the monitor will repeat the filtering routine on the calculated restriction (from deltaP sensor) and from the estimated soot in the DPF (from soot model). The ratio of restrictions (actual vs soot estimate) is compared to a threshold. If the ratio is less than a threshold, an error flag is set. The monitor allows for multiple monitoring sessions in order to provide debouncing before declaring the monitor as a pass or fail. When a sufficient number of sessions have been completed, the monitor is declared complete. The number of sessions with a failed result is compared to a threshold. If the number of failed sessions is greater than a threshold, the monitor is declared as failed and the code is set.

| Monitor Summary: | |
|---|---|
| DTCs | P2002 – Diesel Particulate Filter Efficiency Below Threshold |
| Monitor execution | P2002: Once per trip after a DPF regeneration |
| Monitor Sequence | None |
| Sensors OK | EGT, DPFP, CKP, ECT (P0117, P0118), EGT13 EGT14, MAF, IAT, DPFdP |
| Monitoring Duration | Once between rengeration events |

| Typical Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| DPF temperature during regen (average of DPF inlet/outlet) | 550 degC | |
| Time above temp threshold in regen | 300 sec | |
| DPF temperature (post-regen, to trigger monitor) | | 400 degC |
| Estimated soot load in DPF | | 38.5 grams |
| Estimated soot consumed due to passive regen | | 10 grams |
| DPF temperature (inlet or outlet) | | 500 degC |
| No codes for sensors used as inputs to the monitor | | |
| Not currently in a regeneration event | | |
| Exhaust volumetric flow | 300 m3/hour | 1800 m3/hour |
| Ambient air temperature | -6.7 decC | |
| Ambient pressure | 74.5 kPa | |
| DPF restriction not being calculated from open loop soot estimation | | |
| Percentage of integrated soot under conditions where soot model is not accurate | | 32% |

| Typical Malfunction Thresholds: |
|---|
| DPF Efficiency Test: (P2002)<br>Ratio of restriction from delta pressure sensor vs soot model is below a threshold for a sufficient number of monitoring sessions. Typical values for thresholds:<br><br>Ratio of restrictions: 0.70 (unitless)<br>Debounce counter for number of failed sessions: 3<br>Counter for number of sessions to declare the monitor complete: 3 |

### DPF Filter Missing Substrate Monitor

The DPF is monitored to ensure that the filter has not been removed.

The DPF Missing Substrate monitor compares the measured pressure upstream of the DPF to a threshold (function of volumetric exhaust flow). A debounce counter will increment when the pressure is below the threshold and decrement if the pressure is above the threshold (clipped to a minimum of 0). When the debounce counter exceeds a threshold, a fault is indicated.

| Monitor Summary: | |
|---|---|
| DTCs | P244A – Diesel Particulate Filter Differential Pressure Too Low |
| Monitor execution | P244A: Continuous while meeting entry conditions |
| Monitor Sequence | None |
| Sensors OK | EGT, DPFP, CKP, ECT (P0117, P0118), EGT13 EGT14, MAF, IAT |
| Monitoring Duration | 90 sec |

| Typical Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Exhaust volumetric flow | 300 m3/hour | 2400 m3/hour |
| Not a regeneration event | | |
| Intake air temperature | -20 deg C | |
| Engine coolant temperature | 50 deg C | |

| Typical Malfunction Thresholds: |
|---|
| <u>DPF Differential Pressure Test: (P244A)</u><br>Measured DPF inlet pressure is below a threshold (function of engine exhaust volumetric flow) for 90 seconds.<br>Typical values for threshold: |

| Flow (m^3/hr) | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2500 |
|---|---|---|---|---|---|---|---|---|
| Pressure (kPa) | 7.99 | 15.02 | 27.94 | 47.13 | 72.80 | 104.94 | 143.45 | 204.61 |

## DPF Frequent Regeneration Monitor

The DPF Frequent Regeneration monitor calculates the distance between aftertreatment regeneration events. The distance between successive regeneration events is calculated and the average distance is calculated for the two most recent regeneration events. If the distance between regen events is below a threshold, a fault is indicated.

| Monitor Summary: | |
|---|---|
| DTC | P2459 – Diesel Particulate Filter Regeneration Frequency |
| Monitor execution | During each completed regeneration event |
| Monitor Sequence | None |
| Sensors OK | DPFP |

| Typical Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Regeneration runs to completion (not aborted by customer input or drive cycle) | | |
| Not in “degraded regen” mode due to DPF pressure sensor error | | |
| Fraction of time spent in speed/load conditions where monitor is reliable | 0.20 | |

| Typical Malfunction Thresholds: |
|---|
| A fault is stored when the average distance between regeneration events is below a threshold. Typical threshold is 42 km. |

## DPF Incomplete Regeneration Monitor

The DPF Incomplete Regeneration monitor is used to detect an event where the DPF is not fully regenerated. If a regeneration event is aborted due to duration and the restriction of the DPF is still above a threshold, a fault is indicated. Upon the first occurrence of an incomplete regen, the system is put into a "degraded" regen mode. Another regen will be forced in approximately 150 miles unless a normal regen is triggered by the soot load first.

| Monitor Summary: | |
|---|---|
| DTC | P24A2 – Diesel Particulate Filter Regeneration Incomplete |
| Monitor execution | During each DPF regeneration cycle |
| Monitor Sequence | None |
| Sensors OK | EGT11, EGT12,EGT13, EGT14, DPFP, INJ |
| Monitoring Duration | 20 minutes (maximum) |

| Typical Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Monitor is activated during Aftertreatment regeneration events | | |
| Ambient air temperature | -6.7 degC | |
| Ambient pressure | 74.5 kPa | |
| Engine speed | 1000 rpm | 3500 rpm |
| Engine Indicated Torque | 150 N-m | 1500 N-m |
| Engine Coolant Temperature | 70 degC | |
| Minimum time with valid entry conditions (function of regen duration) | | |

| Typical Malfunction Thresholds: |
|---|
| If the restriction is above a threshold, a fault is indicated. |

## DPF Feedback Control Monitors

The system is monitored to ensure that closed loop control of the regeneration event is initiated within a reasonable period of time. The monitor runs during a regeneration event and compares the time in closed loop control to the total time in regen. If the time in closed loop control is less than a threshold (a function of total time in regen), then a fault is indicated.

If the closed loop controller is saturated at its limits and the temperature is not within the desired limit, a timer will increment. If control is regained, the timer will decrement. At the end of the regeneration event, if this timer exceeds a threshold (a function of total time in regen), a fault is indicated

Note: Ford Motor Company 2011 diesel programs are using in-cylinder post injection to achieve regeneration, not external exhaust injection. The Post injection is monitored during this feedback monitor; there is no additional monitor for "active / intrusive injection"

| Monitor Summary: | |
|---|---|
| DTC | P24A0 – DPF Temperature Control<br>P249F – Excessive Time To Enter Closed Loop DPF Regeneration Control |
| Monitor execution | During an active regeneration event |
| Monitor Sequence | None |
| Sensors OK | TIA, TCO, AMP, EGT11, EGT12, EGT13, EGT14 |
| Monitoring Duration | Once per regeneration event |

| Typical Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Speed | 1200 rpm | 3500 rpm |
| Indicated Torque Setpoint | 200 Nm | 1500 Nm |
| Ambient Temperature | -6.7 deg C | |
| Coolant Temperature | 70 deg C | |
| Barometric Pressure | 74.5 kPa | |

| Typical Malfunction Thresholds: |
|---|
| P249F - If the time in closed loop operation is less than a threshold (function of total time in regen), a fault is indicated.<br><br>P24A0 - If the difference between desired and actual temperature is greater than a threshold for a sufficient period of time, a fault is indicated. |

## DPF Restriction Monitor

The DPF is monitored for conditions where it may be overloaded. The monitor compares the calculated restriction of the DPF to two thresholds. By exceeding the first threshold for a sufficient period of time, a wrench light will be illuminated. By exceeding the second threshold for a sufficient period of time, a wrench light and a MIL will be illuminated and engine output will be limited and EGR is disabled.

| Monitor Summary: | |
|---|---|
| DTCs | P2463 – Diesel Particulate Filter Restriction – Soot Accumulation<br>P246C - Diesel Particulate Filter Restriction – Forced Limited Power |
| Monitor execution | Continuous while meeting entry conditions |
| Monitor Sequence | None |
| Sensors OK | DPFP |
| Monitoring Duration | 300 seconds |

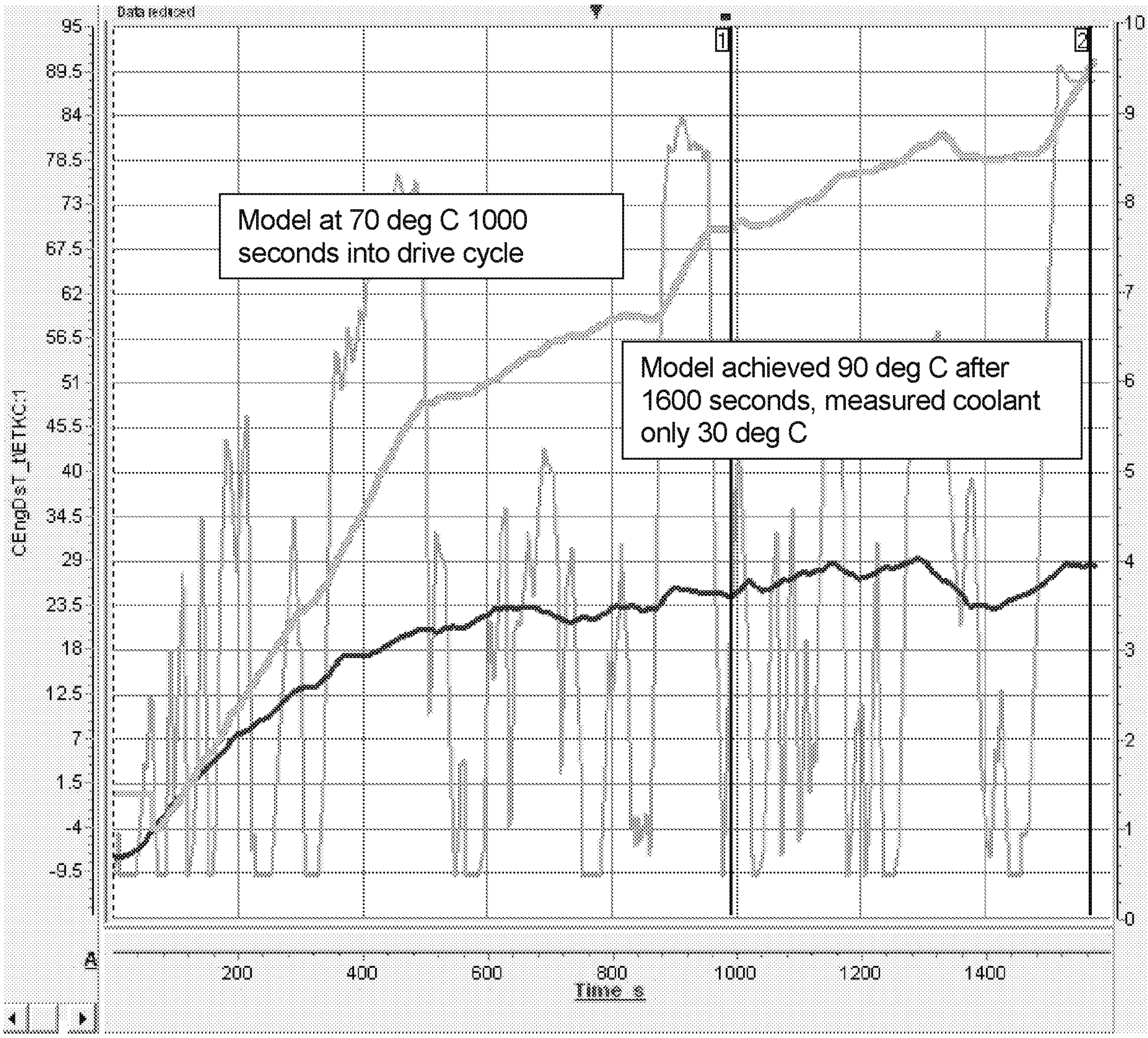
| Typical Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Speed | 625 rpm | |

| Typical Malfunction Thresholds: |
|---|
| Diesel Particulate Filter Restriction – Soot Accumulation (P2463) (Wrench Light)<br>Calculated normalized restriction is 1.5 times the normal value for soot load.<br><br>Diesel Particulate Filter Restriction – Forced Limited Power (P246C) (Immediate MIL and Wrench Light)<br>Calculated normalized restriction is 2.0 times the normal value for soot load. |

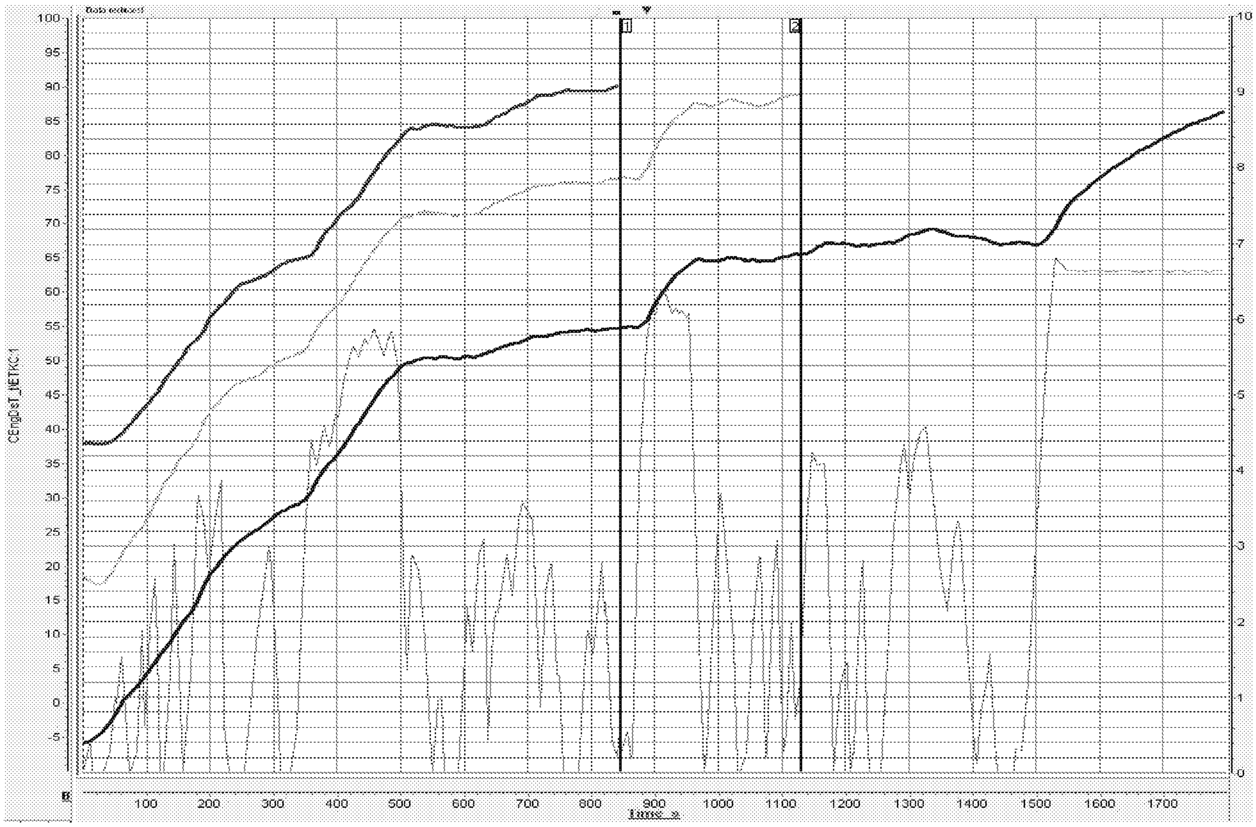
## Thermostat Monitor

The Thermostat Monitor checks that the thermostat is operating properly by modeling Engine Coolant Temperature (ECT) based on engine fueling, engine speed, vehicle speed, and the ambient temperature. There are increment and decrement portions to the model; the increment is based on engine speed and fuel quantity, while the decrement is derived from calculated radiator efficiency based on coolant delta temp to ambient and vehicle speed. The model is delayed by 60 seconds after engine start to negate potential errors due to block heater use. It is also suspended while in catalyst warm-up mode due to errors in fuel quantity heat being contributed to the coolant.

Once that estimation reaches the thermostat start-to-open temperature, if the actual measured ECT has not reached a minimum warm-up temperature and the driver has not spent too much time in part fuel cut off (over 30%), too low load (over 70%), too high vehicle speed (over 70%), or too low vehicle speed (over 70%) - then the thermostat is determined to be stuck open.




Warmup at -7 deg C on Unified Drive Cycle, DTC set when modeled temp reaches 90 deg C. Measured coolant temperature was only at 30 deg C.



Warm-up profiles with nominal thermostat on Unified Drive Cycle at -7, 21 and 38 deg C ambient start temperatures.

| **Thermostat Monitor:** | | | |
|---|---|---|---|
| DTCs | P0128 –Coolant Temp Below Thermostat Regulating Temperature | | |
| Monitor Execution | Continuous | | |
| Monitor Sequence | None | | |
| Sensors OK | Engine Coolant Temperature (ECT), Intake Air Temperature (IAT), Vehicle Speed (VS) | | |
| Typical Monitoring Duration | Nominal time it takes for engine to warm up to thermostat "Start-To–Open" temperature – see approximate times below. (Note: Unified Drive Cycle is 23.9 minutes long) | | |
| | Ambient Temperature | Drive Cycle | Completion Time |
| | -7 deg C | Unified Drive Cycle + 70 mph cruise | 33 min |
| | 21 deg C | Unified Drive Cycle | 19 min |
| | 38 deg C | Unified Drive Cycle | 14 min |

| Typical Thermostat Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Modeled engine coolant temperature | 90 deg C | |
| Engine coolant temperature at start | -7 deg C | 54 deg C |
| Intake air temperature at start | -7 deg C | |
| Ratio of time that the vehicle speed is above, 85 km/hr, to the total monitoring time | | 70% |
| Ratio of time that the engine fueling is below 20 mg/str to the total monitoring time | | 30% |
| Ratio of time that the engine torque is below 60 n/m to the total monitoring time | | 70% |
| Ratio of time that the vehicle speed is below 45 km/hr to the total monitoring time | | 70% |

| Typical Thermostat Monitor Malfunction Thresholds: |
|---|
| Measured Engine Coolant Temperature < 70 deg C when modeled coolant temp > 90 deg C |

## Primary Coolant Temp Dynamic Monitoring

To ensure the primary ECT sensor has not stuck below normal operating range, a simple dynamic check to verify a minimum rise in coolant temperature over a calibratable time has been implemented. If coolant temperature at start is greater than -35 deg C and less than 54 deg C, the monitor is enabled. At -35 deg C, the coolant is expected to rise up to -7 deg C in 291 seconds or less. If -7 deg C coolant temp. is not achieved in the required 291 second timeframe, a fault is detected. At a -7 deg C start temp, the coolant is expected to rise to 40 deg C in 5450 seconds- assuming worst case with EGR off, vehicle idling in neutral with heater on. Again, if the minimum temperature is not achieved in the required time, a fault is detected. This diagnostic is used in conjunction with the oil vs. coolant plausibility check, thermostat model, and SRC checks to verify proper ECT operation and engine warm-up.

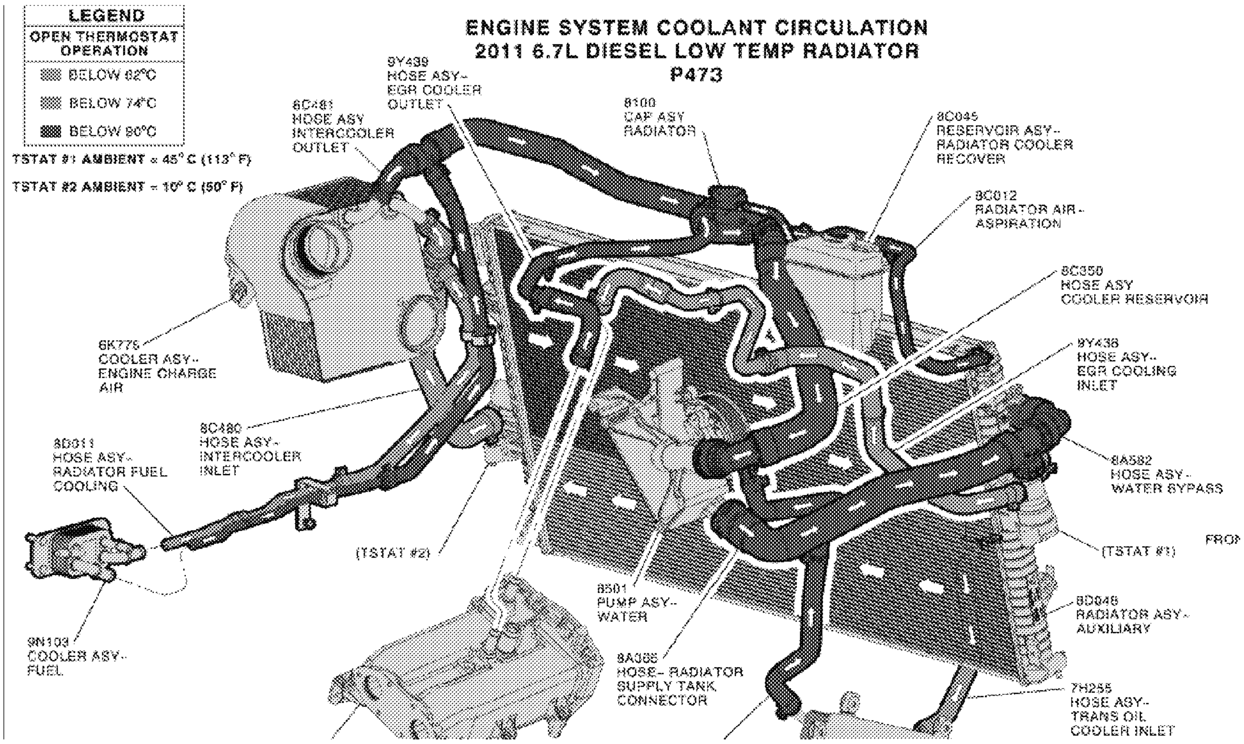
| ECT Dynamic Monitor: | |
|---|---|
| DTCs | P0116 - Engine Coolant Temperature Sensor 1 Circuit Range/Performance |
| Monitor Execution | Once per trip |
| Monitor Sequence | None |
| Sensors OK | ECT |
| Typical Monitoring Duration | 291 seconds at -35 deg C start temp. idle only<br>5150 seconds at -7 deg C start temp, idle only |

| Typical ECT Dynamic Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine coolant temperature | -35 deg C | 54 deg C |
| Engine speed | 400 rpm | |

| Typical ECT Dynamic Monitor Malfunction Thresholds: |
|---|
| 291 seconds at -35 deg C start temp to rise to -7 deg C<br>5150 seconds at -7 deg C start temp to rise to 40 deg C |

## Secondary Coolant Temp Dynamic Monitoring

The 6.7L engine has a secondary coolant loop with two thermostats, a 20C thermostat for the charge air cooler and fuel cooler, and a 45C thermostat for the EGR cooler and trans cooler. System schematic below:




The dynamic check to detect a stuck ECT2 sensor is identical in function to the dynamic check used for the primary coolant loop. A minimum rise is expected over a calibratable amount of time,

| ECT2 Dynamic Monitor: | |
|---|---|
| DTCs | P2183 - Engine Coolant Temperature Sensor 2 Circuit Range/Performance |
| Monitor Execution | Once per trip |
| Monitor Sequence | None |
| Sensors OK | ECT2, |
| Typical Monitoring Duration | 5750 sec at -35C, 200 at 25C |

| Typical ECT2 Dynamic Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| ECT2 | -35 deg C | 45 deg C |
| Engine Speed | 400 rpm | |

| Typical ECT2 Dynamic Monitor Malfunction Thresholds: |
|---|
| within the time duration, must reach 25C |

## COLD START EMISSION REDUCTION STRATEGY MONITORING

### Cold Start Emission Reduction System Monitor (Only Chassis Cert. Applications)

The Post DOC temperature is monitored during a cold start for the CSER System Monitor. The modeled Post DOC temperature rise is compared to the measured Post DOC temperature rise. Specifically, the monitor compares the maximum temperature rises. An error is detected if the difference between the modeled and measured Post DOC maximum temperature rise is above a threshold.

Error if DTPost_DOC_model – DTPost_DOC_meas > Threshold

- DTPost_DOC_model = MAX(TPost_DOC_model) – INIT(TPost_DOC_model)
- MAX(TPost_DOC_model) = maximum of TPost_DOC_model during EOM3 ON and calibratable time after EOM3 switched to OFF
- INIT(TPost_DOC_model) = TPost_DOC_model when EOM3 ON
- Same method is used to calculate DTPost_DOC_meas

An error will also be detected if the modeled vs. measured post DOC maximum temperature rise is above a threshold.

| CSER System Check Operation: | |
|---|---|
| DTCs | P050E – Cold Start Engine Exhaust Temperatures Too Low |
| Monitor execution | During EOM3 Operation, once per drive cycle |
| Monitor Sequence | None |
| Sensors OK | TIA, EGT1, EGT2, MAF, MAP, P3 |
| Monitoring Duration | 300 seconds |

| Typical CSER System entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine in EOM3 Mode | | |
| Ambient Temperature | 0 deg C | |
| Ambient Pressure | 75 kPa | |
| Engine Coolant Temperature | | 50 deg C |
| Engine Soak Time | 6 hr | |
| Engine Speed | 750 rpm | 2300 rpm |
| Engine Load (Torque) | 50 Nm | 700 Nm |
| Percentage of time with speed/torque conditions met | 50% | |
| No Sensor Errors | | |
| No Error in Air Path, EGR, Boost, Fuel Path, Fuel Quantity, Timing and Pressure Monitors | | |

| Typical CSER System malfunction thresholds: |
|---|
| Modeled vs. Measured Post DOC Temperature Rise > 45 deg C. |

## Cold Start Emission Reduction Component Monitor

For all 2010 and subsequent model year vehicles that incorporate a specific engine control strategy to reduce cold start emissions, the OBD II system must monitor the components to ensure proper functioning. The monitor works by validating the operation of the components required to achieve the cold start emission reduction strategy, namely intake throttle and fuel balancing control.

### Cold Throttle Valve Actuator Jammed Detection

Duplicate fault storage of throttle valve jammed detection exists, which can only set/clear in EOM3.

| Cold Throttle Actuator Jammed Valve Check Operation: | |
|---|---|
| DTCs | P02E1 – Diesel Intake Air Flow Control Performance, |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Cold Throttle Actuator Jammed Valve Entry Conditions: |
|---|

See Throttle Valve Actuator Jammed Detection

Engine Operating mode is EOM3

| Typical Cold Throttle Jammed Valve Check (P02E1) Malfunction Thresholds: |
|---|
| A P02E1 is set in EOM3. |

### Cold EGR Valve Actuator Jammed Detection

Duplicate fault storage of EGR valve jammed detection exists, which can only set/clear in EOM3.

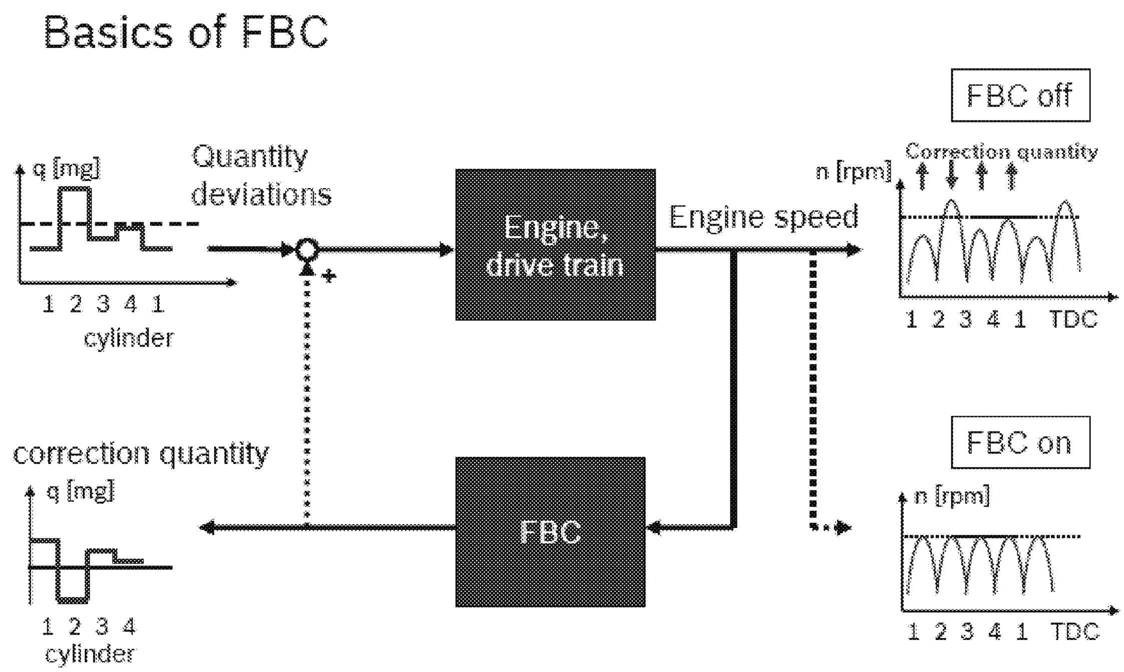
| EGR Valve Jammed Check Operation: | |
|---|---|
| DTCs | P042E – Exhaust Gas Recirculation "A" Control Stuck Open |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Actuator Jammed Valve Entry Conditions: |
|---|
| See EGR Valve Actuator Jammed Detection |
| Engine Operating mode is EOM3 |

| Typical EGR Valve Jammed Check (P042E) Malfunction Thresholds: |
|---|
| A P042E is set in EOM3. |

**Cold FBC (Only Chassis Cert Applications)**

Fuel Balancing Control is an algorithm designed to reduce differences in injected fuel quantity from cylinder to cylinder. The increase in crankshaft speed due to individual cylinder combustion events is measured. The amount of fuel injected to each cylinder is then adjusted up or down to minimize the difference in increase in crankshaft speed from cylinder to cylinder. The total amount of fuel injected among all cylinders remains constant. The Cold FBC runs exactly the same as the normal FBC monitor, only difference is that it will run during EOM3 instead of EOM0. The concept is shown in the graphic below.




FBC operates in closed-loop control in an engine speed range of 500-3000 RPM, and a commanded injection quantity of 3.5 – 90 mg/stroke. The maximum allowed correction in fuel quantity for an individual cylinder is given by the following table.

| CSER Component Monitor: Cold FBC Control Limits: | | | |
|---|---|---|---|
| | Injection quantity requested before FBC correction (mg/stroke) | | |
| | 3.5 | 7.5 | 15 |
| Maximum allowable FBC correction (mg/stroke): | 4 | 8 | 15 |

When the current correction for a given cylinder exceeds 90% of the allowable correction for the current conditions, a code is set.

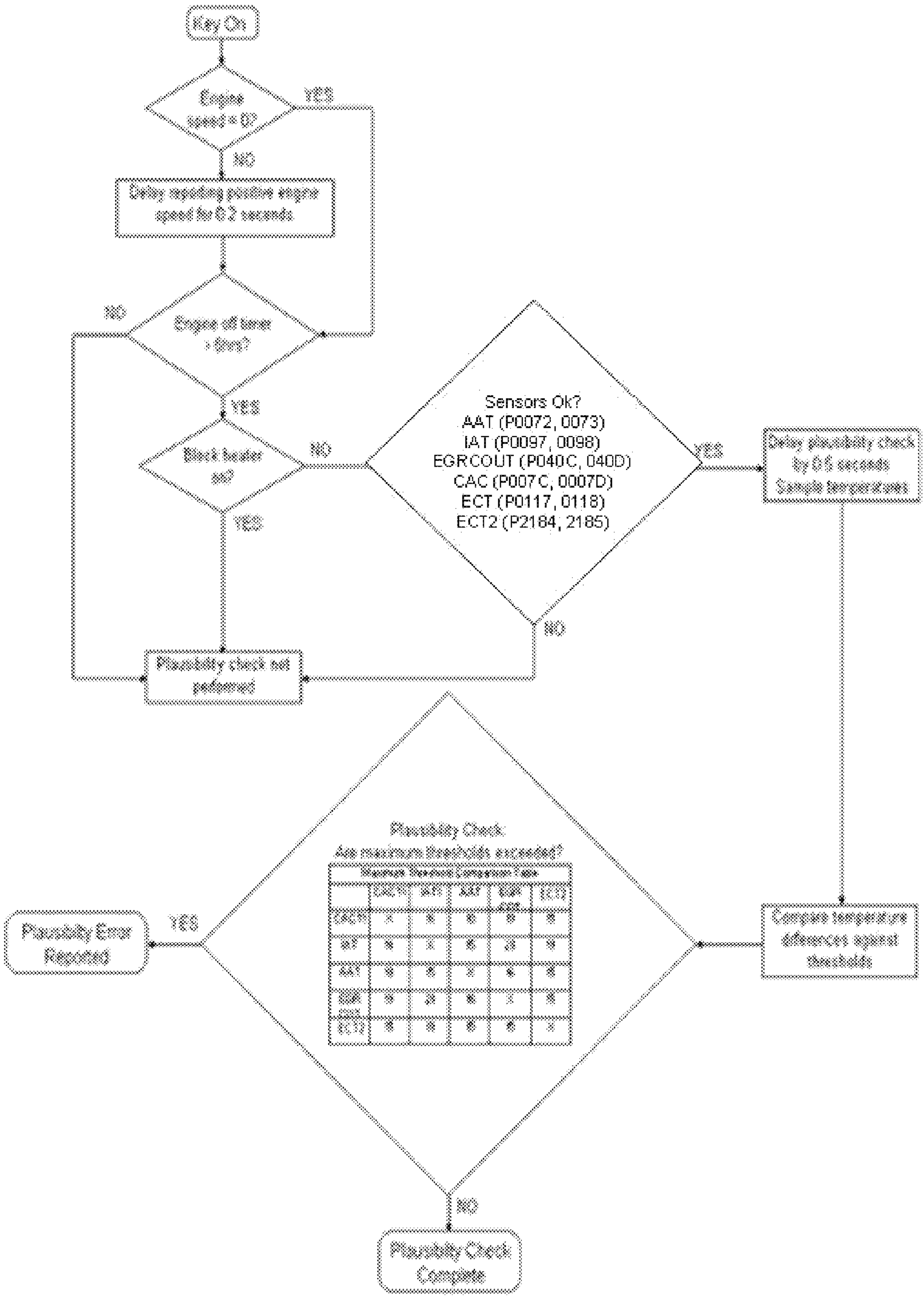
| CSER Component Monitor: Cold FBC Monitor Operation: | |
|---|---|
| DTCs | P0263 – Cylinder #1 Contribution/Balance<br>P0266 – Cylinder #2 Contribution/Balance<br>P0269 – Cylinder #3 Contribution/Balance<br>P0272 – Cylinder #4 Contribution/Balance<br>P0275 – Cylinder #5 Contribution/Balance<br>P0278 – Cylinder #6 Contribution/Balance<br>P0281 – Cylinder #7 Contribution/Balance<br>P0284 – Cylinder #8 Contribution/Balance |
| Monitor Execution | P0263 – During EOM3 after a cold start<br>P0266 – During EOM3 after a cold start<br>P0269 – During EOM3 after a cold start<br>P0272 – During EOM3 after a cold start<br>P0275 – During EOM3 after a cold start<br>P0278 – During EOM3 after a cold start<br>P0281 – During EOM3 after a cold start<br>P0284 – During EOM3 after a cold start |
| Monitor Sequence | None |
| Sensors OK | Crankshaft Position Sensor "A" Circuit (P0335)<br>Crankshaft Position Sensor "A" Circuit Range/Performance (P0336) |
| Typical Monitoring Duration | 10 sec |

| Typical CSER Component Monitor: Cold FBC Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| EOM3 Active | | |
| Engine speed | 500 rpm | 3000 rpm |
| Injection quantity | 3.5 mg/stroke | 90 mg/stroke |
| Engine Temperature | | |
| Barometric Pressure | | |
| FBC wheel learn complete | | |

| Typical CSER Component Monitor: Cold FBC Monitor Malfunction Thresholds: |
|---|
| If the current correction for the injector exceeds 90% of the allowable correction for current operation conditions, the code is set. |

## Air Temperature Rationality Test

An air temperature rationality test is performed once every drive cycle, after a long soak of 6 hours or greater. At key on, a temperature sample is taken of each of the following sensors: Ambient Air (AAT), Intake Air (IAT), Charge Air Cooler outlet (CACT1), EGR Cooler outlet (EGT COT), and Secondary Coolant Temperature (ECT2). Once a cold start has been confirmed, the temperature samples are compared against each other, and the temperature differences compared against a threshold. One sensor must fail plausibility with all four other sensors to set a fault for the sensor in question. If one or more sensors fail plausibility with three or fewer sensors, a general temperature plausibility fault is set. If a block heater has been detected, or if any sensor has been flagged for a pending signal range malfunction, the plausibility check is not performed.




Air Temperature Plausibility Check Flow Chart

| Ambient Air Temperature (AAT) Sensor Circuit Check: | |
|---|---|
| DTCs | P0072 – Ambient Air Temperature Circuit Low<br>P0073 – Ambient Air Temperature Sensor Circuit High |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | 2 sec. |

| Typical Ambient Air Temperature Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 9 V | 16.25 V |
| Key On | | |

| Typical Ambient Air Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < 0.10 V (-40 deg C) or voltage > 4.99 V (108 deg C) |

## Ambient Air Temperature Physical Range Check

A physical range check of ambient air temperature is performed on each drive cycle. It compares the measured value of ambient air temperature to a threshold of 72 deg C, if the threshold is exceeded a fault is detected.

| Ambient Air Temperature (AAT) Sensor Physical Range Check: | |
|---|---|
| DTCs | P0070 - Ambient Air Temperature Circuit |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | AAT (P0072, P0073), |
| Typical Monitoring Duration | 4 seconds |

| Typical Ambient Air Temperature Sensor Plausibility Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 9 V | 16.25 V |
| Key On | | |

| Typical Ambient Air Temperature Sensor Plausibility Check Malfunction Thresholds: |
|---|
| If AAT > 72 deg C for 4 seconds a fault is detected and the code is set. |

| Ambient Air Temperature Rationality Check | |
|---|---|
| DTCs | P0071 – Ambient Air Temperature Sensor Range/Performance |
| Monitor Execution | Once per driving cycle. The check is disabled if a block heater is in use. |
| Monitor Sequence | None |
| Sensors OK | AAT (P0072, P0073), IAT1 (P0112, P0113), EGT11 (P0548, P0549), EGRCOT (P040D, P040C), ECT (P0117, P0118), EOT (P0197, P0198), CACT1 (P007C, P007D) |
| Typical Monitoring Duration | 0.5 sec |

| Typical Ambient Air Temperature Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Off Time | 6 hrs | N/A |
| Engine coolant temperature | -35 deg C | 121 deg C |

| Typical Ambient Air Temperature Rationality Check Thresholds: | |
|---|---|
| AAT Rationality is confirmed against 4 other sensors (absolute temperature difference thresholds): | |
| CACT1 | 10 deg C |
| IAT1 | 15 deg C |
| EGRCOT | 16 deg C |
| ECT2 | 20 deg C |

## Ambient Air Temperature Plausibility Check

An air temperature vs. environmental temp plausibility check is performed on each drive cycle. It compares the absolute difference of IAT1 and AAT, if the difference is greater than 55C for 5 minutes and vehicle speed is above 80.5 km/h when coolant temp is less than 100 deg C, a fault is detected.

| Ambient Air Temperature (AAT) Sensor Plausibility Check: | |
|---|---|
| DTCs | P009A - Intake Air Temperature /Ambient Air Temperature Correlation |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | 5 minutes |

| Typical Ambient Air Temperature Sensor Plausibility Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 9 V | 16.25 V |
| Vehicle Speed | 80.5 km/h | |
| IAT1 Temp | -40 deg C | 121 deg C |
| Coolant Temp | -40 deg C | 100 deg C |
| Environmental Temp | -40 deg C | 80 deg C |
| Key On | | |

| Typical Ambient Air Temperature Sensor Plausibility Check Malfunction Thresholds: |
|---|
| If IAT1 – AAT > 55 deg C for 5 minutes, a fault is detected and the code is set. |

| Charge Air Cooler (CACT1) Sensor Circuit Check: | |
|---|---|
| DTCs | P007C – Charge Air Cooler Temperature Sensor Circuit Low<br>P007D – Charge Air Cooler Temperature Sensor Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | 4 sec |

| Typical Charge Air Cooler Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < 0.092 V (161 deg C) or voltage > 4.90 V (-43 deg C) |

| Charge Air Cooler Temperature (CACT1) Rationality Check: | |
|---|---|
| DTCs | P007B - Charge Air Cooler Temperature Sensor Circuit Range/Performance |
| Monitor Execution | Once per drive cycle. The check is disabled if a block heater is in use. |
| Monitor Sequence | None |
| Sensors OK | AAT (P0072, P0073), IAT1 (P0112, P0113), EGT11 (P0548, P0549), EGRCOT (P040D, P040C), ECT (P0117, P0118), EOT (P0197, P0198), CACT1 (P007C, P007D) |
| Typical Monitoring Duration | 0.5 sec |

| Typical Charge Air Cooler Temperature Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Off Time | 6 hrs | |
| Coolant Temp | -35 deg C | 121 deg C |

| Typical Charge Air Cooler Temperature Functional Thresholds: | |
|---|---|
| CACT1 Rationality is confirmed against 4 other sensors (absolute temperature difference thresholds): | |
| AAT | 10 deg C |
| IAT1 | 16 deg C |
| EGRCOT | 19 deg C |
| ECT2 | 20 deg C |

| Intake Air Temperature (IAT) Sensor Circuit Check: | |
|---|---|
| DTCs | P0112 - Intake Air Temperature Sensor Circuit Low<br>P0113 - Intake Air Temperature Sensor Circuit High |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | 4 sec. |

| Typical Intake Air Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < 0.10 volts (137 deg C) or voltage > 4.91 volts (-25 deg C) |

| Intake Air Temperature  Rationality Check | |
|---|---|
| DTCs | P0111 – Temperature Sensor Circuit Range/Performance |
| Monitor Execution | Once per drive cycle. The check is disabled if a block heater is in use. |
| Monitor Sequence | None |
| Sensors OK | AAT (P0072, P0073), IAT1 (P0112, P0113), EGT11 (P0548, P0549), EGRCOT (P040D, P040C), ECT (P0117, P0118), EOT (P0197, P0198), CACT1 (P007C, P007D) |
| Typical Monitoring Duration | 0.5 sec |

| Typical Intake Air Temperature Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Off Time | 6 hrs | |
| Coolant Temp | -35 deg C | 121 deg C |

| Typical Intake Air Temperature Functional Thresholds: | |
|---|---|
| IAT Rationality is confirmed against 4 other sensors (absolute temperature difference thresholds): | |
| AAT | 15 deg C |
| CACT1 | 16 deg C |
| EGTCOT | 20 deg C |
| ECT2 | 20 deg C |

| EGR Cooler Downstream Temperature (EGR COT) Sensor Circuit Check: | |
|---|---|
| DTCs | P040C – Exhaust Gas Recirculation Temperature Sensor Circuit Low<br>P040D – Exhaust Gas Recirculation Temperature Sensor Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | 3 sec. |

| Typical EGR Cooler Downstream Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < 0.10 volts (961 deg C) or voltage > 4.90 volts (-46 deg C) |

| EGR Cooler Downstream Temperature Rationality Check | |
|---|---|
| DTCs | P040B – Exhaust Gas Recirculation Temperature Sensor Circuit Range/Performance |
| Monitor Execution | Once per drive cycle. The check is disabled if a block heater is in use. |
| Monitor Sequence | None |
| Sensors OK | AAT (P0072, P0073), IAT1 (P0112, P0113), EGT11 (P0548, P0549), EGRCOT (P040D, P040C), ECT (P0117, P0118), EOT (P0197, P0198), CACT1 (P007C, P007D) |
| Typical Monitoring Duration | 0.5 sec |

| Typical EGR Cooler Downstream Temperature Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Off Time | 6 hrs | |
| Coolant Temp | -35 deg C | 121 deg C |

| Typical EGR Cooler Downstream Temperature Functional Thresholds: | |
|---|---|
| EGRCOT Rationality is confirmed against 4 other sensors (absolute temperature difference thresholds): | |
| AAT | 16 deg C |
| CACT1 | 19 deg C |
| IAT1 | 20 deg C |
| ECT2 | 20 deg C |

| Secondary Engine Coolant Temperature (ECT2) Sensor Circuit Check: | |
|---|---|
| DTCs | P2184 - Engine Coolant Temperature Sensor 2 Circuit Low<br>P2185 - Engine Coolant Temperature Sensor 2 Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not Applicable |
| Typical Monitoring Duration | 2 sec. |

| Typical Secondary Engine Coolant Temperature Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Key On | | |
| Battery Voltage | 9 V | 16.25 V |

| Typical Secondary Engine Coolant Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < 0.10 (163 deg C) volts or voltage > 4.91 volts (-44 deg C) |

| Secondary Engine Coolant Temperature Rationality Check | |
|---|---|
| DTCs | P2182 – Engine Coolant Temperature Sensor 2 Circuit |
| Monitor Execution | Once per drive cycle. The check is disabled if a block heater is in use. |
| Monitor Sequence | None |
| Sensors OK | AAT (P0072, P0073), IAT1 (P0112, P0113), EGT11 (P0548, P0549), EGRCOT (P040D, P040C), ECT (P0117, P0118), EOT (P0197, P0198), CACT1 (P007C, P007D) |
| Typical Monitoring Duration | 0.5 sec |

| Typical Secondary Engine Coolant Temperature Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Off Time | 6 hrs | |
| Coolant Temp | -35 deg C | 121 deg C |

| Typical Secondary Engine Coolant Temperature Functional Thresholds: | |
|---|---|
| ECT2 Rationality is confirmed against 4 other sensors (absolute temperature difference thresholds): | |
| AAT | 20 deg C |
| CACT1 | 20 deg C |
| IAT1 | 20 deg C |
| EGRCOT | 20 deg C |

## Barometric Pressure and Manifold Absolute Pressure

| Barometric Pressure (BP) Sensor Circuit Check: | |
|---|---|
| DTCs | P2227 – Barometric Pressure Sensor "A" Circuit Range/Performance<br>P2228 – Barometric Pressure Circuit Low Input<br>P2229 – Barometric Pressure Circuit High Input |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | P2227 – 1 sec<br>P2228, P2229 –.5 sec. |

| Typical Barometric Pressure Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Battery voltage (IVPWR) | 9 V | 16.25 V |

| Typical Barometric Pressure Sensor Circuit Check Malfunction Thresholds: |
|---|
| P2227 – Observed pressure less than 50 kPa<br>P2228 - Voltage less than 0.25 V. (6.3 kPa)<br>P2229 - Voltage greater than 4.85 V. (115 kPa) |

| Manifold Absolute Pressure (MAP) Sensor Circuit Check: | |
|---|---|
| DTCs | P0107 - Manifold Absolute Pressure/BARO Sensor Low Input<br>P0108 - Manifold Absolute Pressure/BARO Sensor High Input |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | P0107, P0108 - 2 sec. |

| Typical Manifold Absolute Pressure Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Key-on | | |
| Battery voltage (IVPWR) | 9 V | 16.25 V |

| Typical Manifold Absolute Pressure Sensor Circuit Check Malfunction Thresholds: |
|---|
| P0107 – Voltage less than .1 V (50 kPa)<br>P0108 – Voltage greater than 4.745 V (390 kPa) |

| Manifold Absolute Pressure (MAP) / Barometric Pressure (BP) Rationality Check: | |
|---|---|
| DTCs | P0069 – MAP/BARO Correlation |
| Monitor Execution | Once per trip |
| Monitor Sequence | None |
| Sensors OK | BARO (P2228, P2229), MAP (P0107, P0108) |
| Typical Monitoring Duration | 1.5 sec. |

| Typical MAP / BP Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| P0069 - MAP / BARO Correlation: | | |
| Key-on | | |
| Battery voltage (IVPWR) | 9 V | 16.25 V |
| Engine Speed (N) | 0 rpm | 437.5 rpm |

| Typical MAP / BP Rationality Check Malfunction Thresholds: |
|---|
| P0069 - The difference between MAP and BARO is greater than 4.5 kPa, or less than -8 kPa. |

## Turbine Upstream Pressure Sensor Plausibility Checks

The turbine upstream pressure sensor has two plausibility checks to determine if the sensor is operating correctly. The first check looks for an offset in the turbine upstream pressure sensor when the engine is not running. This check compares the absolute value of the difference between the measured turbine upstream pressure and the measured environmental pressure under specific entry conditions. If the pressure difference exceeds the threshold, for a predetermined amount of time while the entry conditions are met, a fault is set.

| Turbine Upstream Pressure Sensor Offset Plausibility Check Operation: | |
|---|---|
| DTCs | P0471– Exhaust Pressure Sensor "A" Circuit Range / Performance |
| Monitor execution | Continuous in with engine off. |
| Monitor Sequence | None |
| Monitoring Duration for stuck midrange | 1.0 seconds to register a malfunction once entry conditions are met. |

| Turbine Upstream Pressure Sensor Offset Entry Conditions | | |
|---|---|---|
| **Entry Condition:** | **Minimum** | **Maximum** |
| Turbine Upstream Pressure Sensor is not Frozen | | |
| Ambient Pressure | 74.5 kPa | |
| Ambient Air Temperature | 5 deg C | |
| Coolant Temperature | 5 deg C | |
| Engine Speed | | 0 rpm |
| Engine Off Time | | 10 sec. |
| No Turbine Upstream Pressure Sensor | | |

| Typical Upstream Turbine Pressure Sensor Plausibility Check Malfunction Thresholds: |
|---|
| \| Turbine Pressure Sensor – Ambient Pressure Sensor \| > 7.5 kPa |

The second check compares the measured pressure upstream of the turbine to a model of the pressure upstream of the turbine under specific entry conditions. If the difference between the measured and modeled pressure is greater than a threshold, for a predetermined amount of time while the entry conditions are met, a fault is set.

| Turbine Upstream Pressure Sensor -Model Plausibility Check Operation: | |
|---|---|
| DTCs | P0474– Exhaust Pressure Sensor "A" Circuit Intermittent / Erratic |
| Monitor execution | Continuous when entry conditions are met. |
| Monitor Sequence | None |
| Monitoring Duration for stuck midrange | 2.0 seconds to register a malfunction once entry conditions are met. |

| Turbine Upstream Pressure Sensor Offset Entry Conditions | | |
|---|---|---|
| **Entry Condition:** | **Minimum** | **Maximum** |
| Turbine Upstream Pressure Sensor is not Frozen | | |
| Coolant Temperature | 50 deg C | |
| Engine Speed | 1300 rpm | 2400 rpm |
| Engine Torque | 500 Nm | 1400 Nm |
| Ambient Air Temperature | 5 deg C | |
| Ambient Pressure | 74.5 kPa | |
| Modeled Exhaust Pressure | 147.5 kPa | 620.0 kPa |
| Air Flow Gradient | | 140 g/s/step |

| Typical Upstream Turbine Pressure Sensor Plausibility Check Malfunction Thresholds: |
|---|
| (Turbine Pressure Model – Turbine Pressure Sensor) > 90.0 kPa |

## Upstream Turbine Pressure Sensor Signal Range Check

| Reductant Pressure Sensor Open/Short Check Operation: | |
|---|---|
| DTCs | P0472 - Exhaust Pressure Sensor "A" Circuit Low<br>P0473 - Exhaust Pressure Sensor "A" Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | 2 seconds to register a malfunction |

| Typical Reductant Pressure Sensor Check Malfunction Thresholds: |
|---|
| Pressure sensor voltage < 0.100 volts or Pressure sensor voltage > 4.8 volts |

## EGR Valve Position Sensor

Analog inputs checked for opens or shorts by monitoring the analog -to-digital (A/D) input voltage.

| EGR Valve Position Sensor Check Operation: | |
|---|---|
| DTCs | P0405 (EGR Sensor "A" Circuit Low)<br>P0406 (EGR Sensor "A" Circuit High) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 3 seconds to register a malfunction |

| Typical EGR Valve position sensor check malfunction thresholds (P0405,P0406): |
|---|
| Voltage < 0.30 volts or Voltage > 4.70 volts |

## Throttle Position Sensor

Analog inputs checked for opens or shorts by monitoring the analog -to-digital (A/D) input voltage.

| Throttle Position Sensor Check Operation: | |
|---|---|
| DTCs | P02E9 (Diesel Intake Air Flow Position Circuit High),<br>P02E8 (Diesel Intake Air Flow Position Circuit Low). |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 3 seconds to register a malfunction |

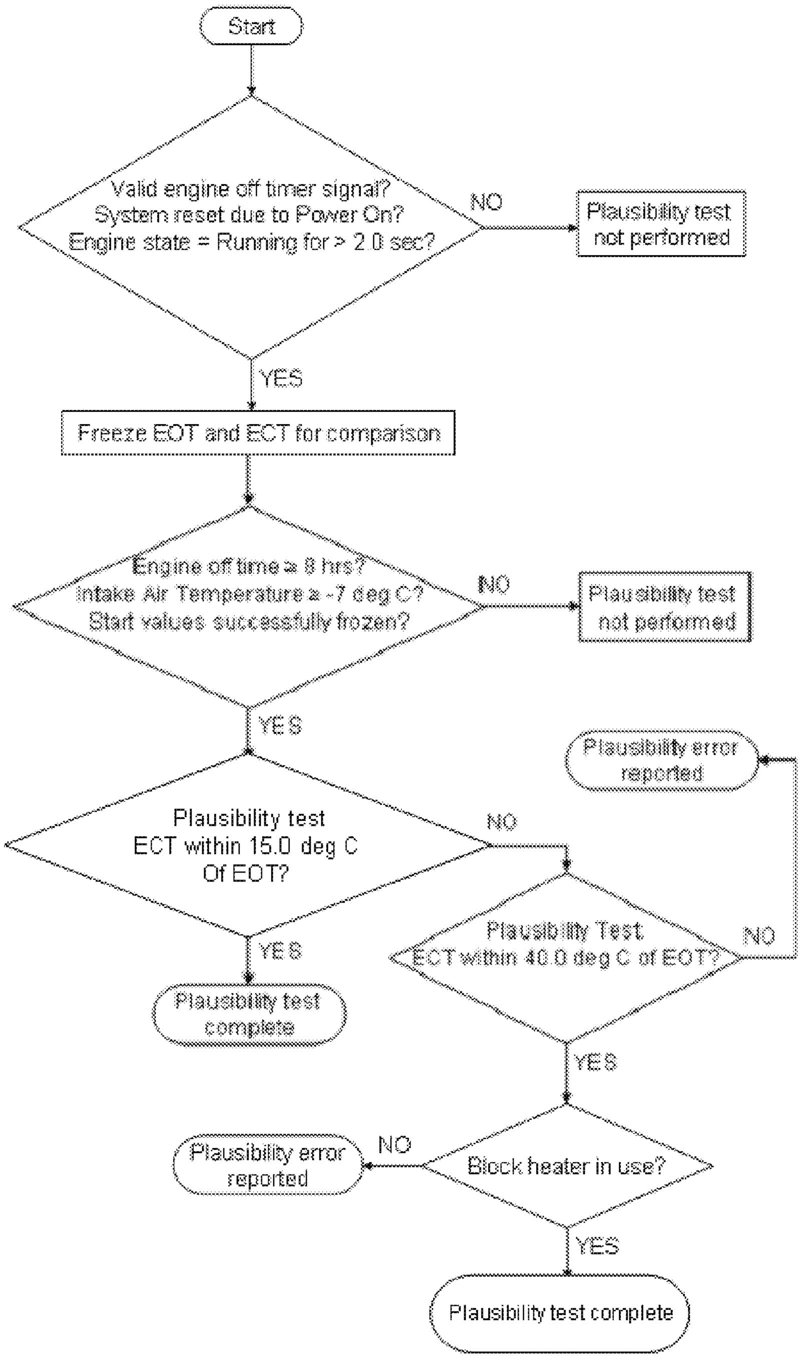
| Typical TP sensor check malfunction thresholds (P02E8,P02E9): |
|---|
| Voltage < 0.08 volts or Voltage > 4.92 volts |

## EGR Downstream Temperature Sensor Dynamic Plausibility Check

Dynamic plausibility of the EGR downstream temperature sensor is checked using the EGR cooler monitor.

## Engine Coolant & Engine Oil Correlation

The engine coolant temperature sensor reading and engine oil temperature sensor readings are tested for plausibility once per drive cycle after a long soak (6hrs or more). The values of the coolant and oil temperature sensor readings are recorded at start up. Once it has been determined that the enable conditions have been achieved, upper and lower thresholds are determined based on the engine-off time. The difference of the initial oil and coolant temperatures are compared to this threshold. If the lower threshold is not achieved, a fault is reported. If the lower threshold is met, but the upper threshold is not achieved and a block heater is not in use, a fault is reported. If a block heater is detected and the diference is greater than 40C, a fault is reported.




ECT/EOT Plausibility Correlation Test Flow Chart

| Engine Coolant Temperature (ECT) Sensor Circuit Check: | |
|---|---|
| DTCs | P0117 - Engine Coolant Temperature Sensor Circuit Low<br>P0118 - Engine Coolant Temperature Sensor Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not Applicable |
| Typical Monitoring Duration | 2 sec. |

| Typical Engine Coolant Temperature Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Key On | | |
| Battery Voltage | 9 V | 16.25 V |

| Typical Engine Coolant Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < 0.10 (163 deg C) volts or voltage > 4.91 volts (-44 deg C) |

| Engine Coolant Temperature Rationality Check | |
|---|---|
| DTCs | P012F – Engine Coolant Temperature / Engine Oil Temperature Correlation |
| Monitor Execution | Once per drive cycle. |
| Monitor Sequence | None |
| Sensors OK | AAT (P0072, P0073), IAT1 (P0112, P0113), ECT (P0117, P0118), EOT (P0197, P0198) |
| Typical Monitoring Duration | Immediate when conditions exist |

| Typical Engine Coolant Temperature Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Off Time | 6 hrs | |
| Intake Air Temp | -7 deg C | |
| Engine “Running” Time | 2 sec | |

| Typical Engine Coolant Temperature Functional Thresholds: | |
|---|---|
| ECT Rationality is confirmed against EOT: | |
| Absolute Temperature Difference | 15 deg C |

| Engine Coolant Temperature in range Rationality Check | |
|---|---|
| DTCs | P0196 –Engine Oil Temperature Sensor Range/Performance |
| Monitor Execution | Once per drive cycle. |
| Monitor Sequence | None |
| Sensors OK | ECT (P0117, P0118), EOT (P0197, P0198) |
| Typical Monitoring Duration | Immediate when conditions exist |

| Typical Engine Coolant Temperature Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Off Time | 6 hrs | |
| Engine Coolant Temp | 70C | |

| Typical Engine Coolant Temperature Functional Thresholds: | |
|---|---|
| ECT Rationality is confirmed against EOT: | |
| Absolute Temperature Difference | 35 deg C |

| Engine Oil Temperature (EOT) Sensor Circuit Check: | |
|---|---|
| DTCs | P0197 - Engine Oil Temperature Sensor Circuit Low<br>P0198 - Engine Oil Temperature Sensor Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not Applicable |
| Typical Monitoring Duration | 2 sec. |

| Typical Engine Oil Temperature Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Key On | | |
| Battery Voltage | 9 V | 16.25 V |

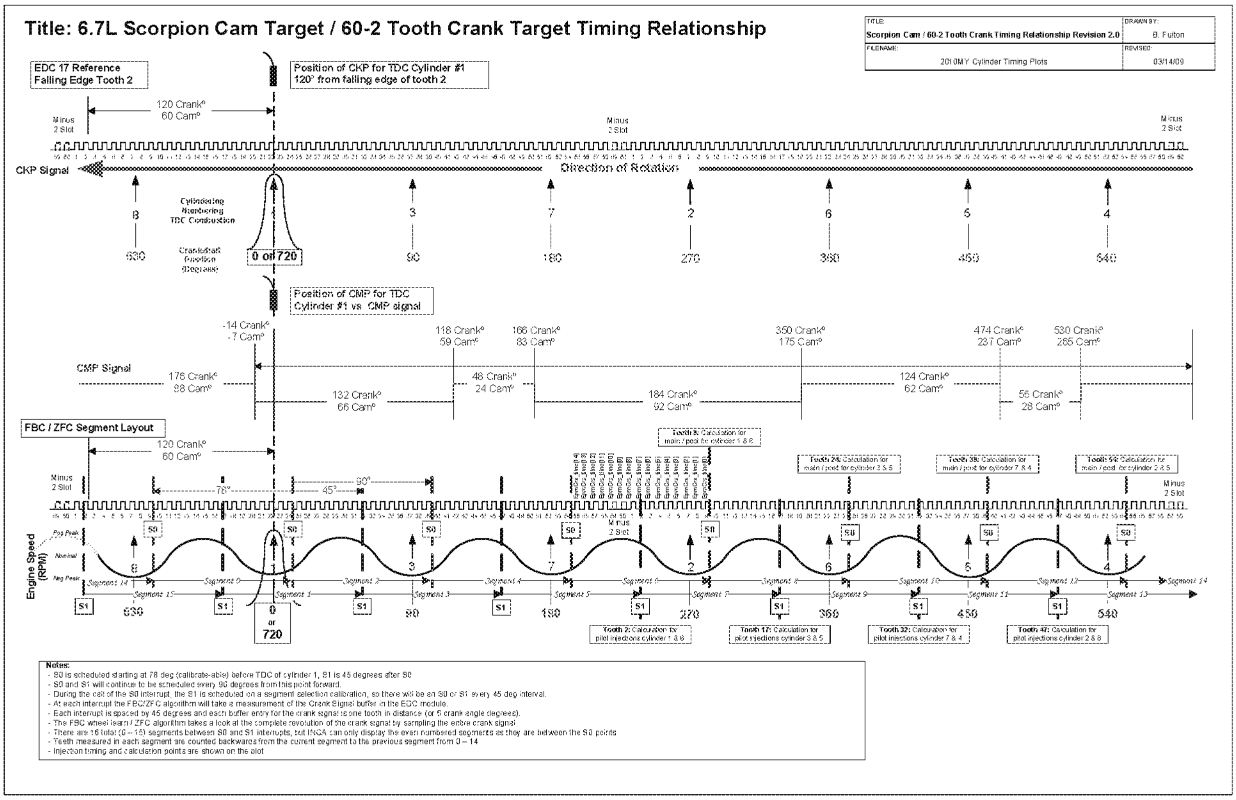
| Typical Engine Oil Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < 0.10 (163 deg C) volts or voltage > 4.91 volts (-44 deg C) |

| Engine Oil Temperature Sensor Circuit Check: | |
|---|---|
| DTCs | P2560 - Engine Oil Temperature Sensor Circuit Low |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ECT and OIL temp. |
| Typical Monitoring Duration | 5 sec. |

| Typical Engine Oil Temperature Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Oil Temp | 70C | |

| Typical Engine Oil Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| Oil Temperature is greater then coolant temperature by 50C |

## Cam and Crank Sensor:




| Camshaft and Crankshaft Sensor Monitor Operation: | |
|---|---|
| DTCs | P0016 – Crankshaft Position - Camshaft Position Correlation (Bank 1 Sensor A)<br>P0315 – Crankshaft Position System Variation Not Learned<br>P0335 – Crankshaft Position Sensor "A" Circuit<br>P0336 – Crankshaft Position Sensor "A" Circuit Range/Performance<br>P0340 – Camshaft Position Sensor "A" Circuit (Bank 1 or single sensor)<br>P0341 – Camshaft Position Sensor "A" Circuit Range/Performance (Bank 1 or single sensor) |
| Monitor Execution | P0016 – Continuous<br>P0315 – Continuous<br>P0335 – Continuous<br>P0336 – Continuous<br>P0340 – Continuous<br>P0341 – Continuous |
| Monitor Sequence | None |
| Sensors OK | P0016 – Sensor Supply Voltage 1 (P06A6), Sensor Supply Voltage 2 (P06A7)<br>P0315 – Sensor Supply Voltage 1 (P06A6), Crankshaft Sensor (P0335, P0336)<br>P0335 – Sensor Supply Voltage 1 (P06A6)<br>P0336 – Sensor Supply Voltage 1 (P06A6)<br>P0340 – Sensor Supply Voltage 2 (P06A7)<br>P0341 – Sensor Supply Voltage 2 (P06A7) |
| Typical Monitoring Duration | P0016 – 3.6 sec ,P0315 – 5000 sec of overrun/decel fuel shut-off<br>P0335 – 1.8 sec, P0336 – 1.8 sec, P0340 – 3 sec, P0341 – 1.2 sec |

| Typical Camshaft and Crankshaft Sensor Monitor Entry Conditions: | | |
| --- | --- | --- |
| Entry condition | Minimum | Maximum |
| P0016 – Engine running or cranking | | |
| P0315 – Overrun/decel fuel shut-off | | |
| P0335 – Engine running or cranking | | |
| P0336 – Engine running or cranking | | |
| P0340 – Engine running or cranking | | |
| P0341 – Engine running or cranking | | |

| Typical Camshaft Sensor Monitor Malfunction Thresholds: |
| --- |
| P0016 – If the location of the gap on the crankshaft sensor wheel occurs at a location on the camshaft sensor wheel that is more than 6 degrees from the expected location for two detection attempts, the code is set<br>P0315 – If after 5000 total seconds of overrun/decel fuel shut-off, the system has been unable to learn crankshaft wheel deviation corrections, the code is set<br>P0335 – If no signal is detected from the crankshaft sensor, the code is set<br>P0336 – If the gap in the 60-2 tooth wheel is not detected for three revolutions, the code is set<br>P0340 – If no signal is detected from the camshaft sensor, the code is set<br>P0341 – If the segment profile detected does not match the segment profile shown in the figure above, the code is set |

## Mass Air Meter

The 6.7L engine utilizes a frequency-based hot film air meter. The digital output varies its period to indicate a change in mass air flow. If the period is outside of a specified range, a fault is detected and the appropriate P-code is set.

| MAF Sensor Circuit Check: | |
|---|---|
| DTCs | P0100 – Mass or Volume Air Flow "A" Circuit<br>P0102 – Mass or Volume Air Flow "A" Circuit Low<br>P0103 – Mass or Volume Air Flow "A" Circuit High |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | P0100 – 1.5 sec<br>P0102 – 2 sec<br>P0103 – 2 sec |

| MAF Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Battery voltage | 9 V | 16.25 V |
| Key on | | |

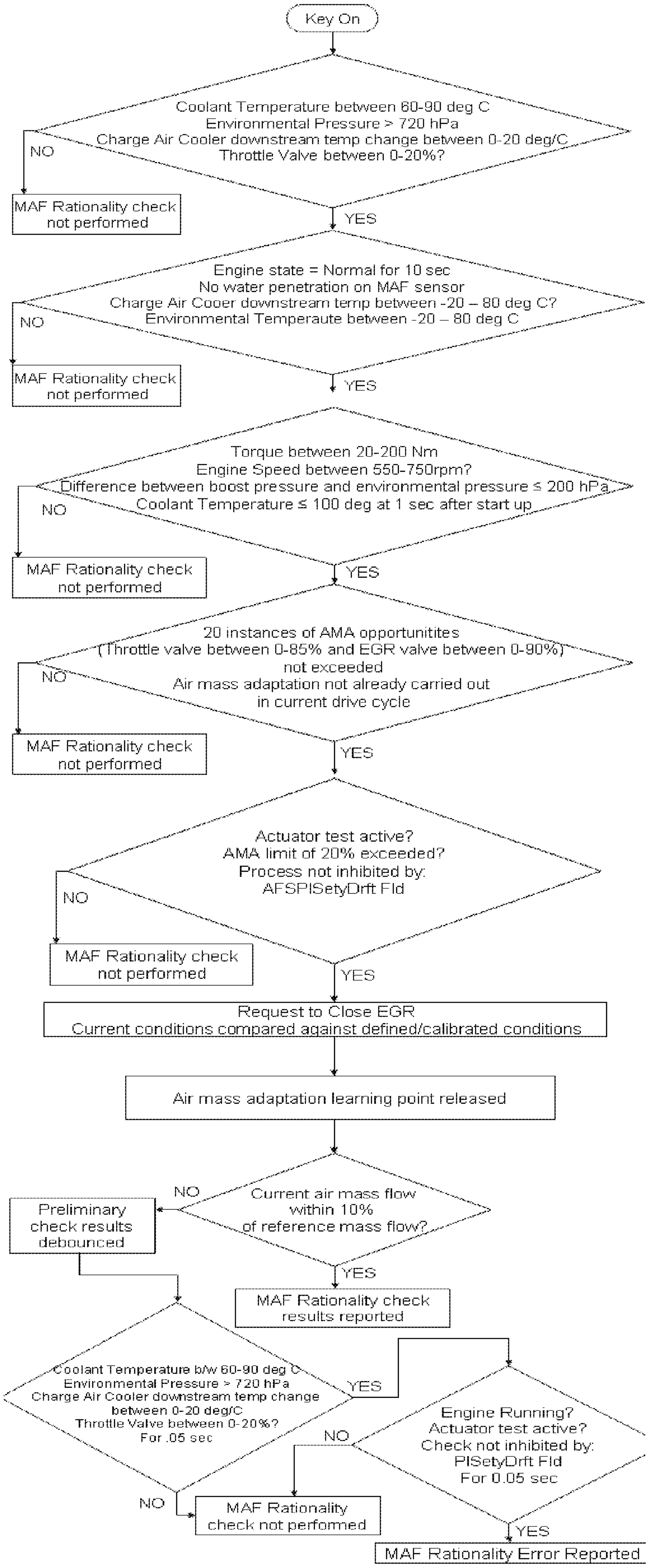
| MAF Sensor Circuit Check Malfunction Thresholds: |
|---|
| P0100 – hard coded, not visible in software<br>P0102 – period less than 62 us<br>P0103 – period greater than 4000 us |

## MAF Rationality Check

A rationality check of the mass air flow sensor is performed each time an air mass adaption (AMA) executes. AMA adapts at two points- one at idle, the other at a specific speed/load. The ratio between the mass air flow and the reference mass air flow is calculated with the EGR valve commanded to the closed position. The release of this plausibility check occurs under strict engine operating and environmental conditions to minimize the affect of outside influences on mass air flow. At each AMA event, the corrected value is stored for each point. These stored values are compared to a threshold, if the stored values are greater than a threshold a fault is detected, as the air meter has drifted outside of its nominal operating range.

In addition to the stored values, the corrected airflow is compared to directly to the modeled airflow during AMA. If the ratio of the corrected airflow and the modeled airflow is less than the threshold, a fault is detected.

The following figure outlines the strategy for the rationality checks.


Key On
Coolant Temperature between 60-90 deg C
Environmental Pressure > 720 hPa
Charge Air Cooler downstream temp change between 0-20 deg/C
Throttle Valve between 0-20%?
NO
MAF Rationality check not performed
YES
Engine state = Normal for 10 sec
No water penetration on MAF sensor
Charge Air Cooer downstream temp between -20 – 80 deg C?
Environmental Temperaute between -20 – 80 deg C
NO
MAF Rationality check not performed
YES
Torque between 20-200 Nm
Engine Speed between 550-750rpm?
Difference between boost pressure and environmental pressure ≤ 200 hPa
Coolant Temperature ≤ 100 deg at 1 sec after start up
NO
MAF Rationality check not performed
YES
20 instances of AMA opportunitites
(Throttle valve between 0-85% and EGR valve between 0-90%)
not exceeded
Air mass adaptation not already carried out
in current drive cycle
NO
MAF Rationality check not performed
YES
Actuator test active?
AMA limit of 20% exceeded?
Process not inhibited by:
AFSPISetyDrft Fld
NO
MAF Rationality check not performed
YES
Request to Close EGR
Current conditions compared against defined/calibrated conditions
Air mass adaptation learning point released
Current air mass flow within 10% of reference mass flow?
NO
Preliminary check results debounced
YES
MAF Rationality check results reported
Coolant Temperature b/w 60-90 deg C
Environmental Pressure > 720 hPa
Charge Air Cooler downstream temp change between 0-20 deg/C
Throttle Valve between 0-20%?
For .05 sec
YES
NO
MAF Rationality check not performed
Engine Running?
Actuator test active?
Check not inhibited by:
PISetyDrft Fld
For 0.05 sec
NO
YES
MAF Rationality Error Reported

| Mass Air Flow Sensor Functional Check Operation: | |
|---|---|
| DTCs | P2073 – Manifold Absolute Pressure/Mass Air Flow - Throttle Position Correlation at Idle<br>P2074 – Manifold Absolute Pressure/Mass Air Flow - Throttle Position Correlation at Higher Load<br>P00BC – Mass or Volume (MAF/VAF) Air Flow “A” Circuit Range/Performance – Air Flow Too Low<br>P2074 – (AMA maturity) |
| Monitor Execution | Once per drive cycle |
| Monitor Sequence | None. |
| Sensors OK | MAF (P0100, P0101, P0102), BP (P2228, P2229), EGRP (P0405, P0406, P0404, P0042E, P042F, P1335), |
| Typical Monitoring Duration | 5 Seconds |

| Typical Mass Air Flow Sensor Functional Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Barometric Pressure | 74.5 kPa | 110 kPa |
| Engine Coolant Temperature | 70 deg C | 112 deg C |
| Throttle Valve | 0% | 20% |
| CAC Downstream Temperature | -20 deg C | 80 deg C |
| Ambient Air Temperature | -20 deg C | 80 deg C |
| Time engine running Normal | 10 seconds | |
| No Water Penetration Detected in Sensor | | |
| Engine Coolant Temperature at 1 second after key on | | 100 deg C |
| Difference in Barometric Pressure versus Pressure in Induction Volume | | 20 kPa |
| Engine Torque | 20 Nm | 200 Nm |
| Engine Speed | 500 rpm | 760 rpm |

| Typical Mass Air Flow Sensor Functional Check Malfunction Thresholds: |
|---|
| P2073, P2074 - If the final AMA stored value in either the idle or higher load cell is greater than 20% or less than -20%, a fault is detected and the appropriate P-code is set.<br>P00BC - Corrected measured airflow / Modeled airflow < 0.7<br>P2074 – If the algorithm cannot learn a stable value for AMA within 10 learning events, this code is set. |

## Air Path Leakage Check

Similar to the mass air flow sensor functional check diagnostics, a rationality check of the mass air flow sensor is performed each time an air mass adaption (AMA) executes which is used to detect instantaneous problems with the air path. At idle, the ratio between the mass air flow and the reference mass air flow is calculated with the EGR valve in the closed position. This ratio is compared against a threshold once AMA has been released. The release of this plausibility check occurs under strict engine operating and environmental conditions to minimize the affect of outside influences on mass air flow. The ratio has an upper and lower limit, and the monitor runs once per drive cycle. A ratio too high indicates a post-turbocharger compressor air path leak, while a ratio too low indicates an EGR valve that is no longer sealing effectively.

| Air Path Leakage Check Operation: | |
|---|---|
| DTCs | P00BC – Mass or Volume (MAF/VAF) Air Flow A Circuit Range/Performance – Air Flow Too Low<br>P00BD - Mass or Volume (MAF/VAF) Air Flow A Circuit Range/Performance – Air Flow Too High |
| Monitor Execution | Once per drive cycle |
| Monitor Sequence | None. |
| Sensors OK | MAF (P0100, P0101, P0102), BP (P2228, P2229), EGRP (P0405, P0406, P0404, P0042E, P042F, P1335), |
| Typical Monitoring Duration | 3 seconds |

| Typical Air Path Leakage Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Barometric Pressure | 74.5 kPa | 110 kPa |
| Engine Coolant Temperature | 70 deg C | 111 deg C |
| Throttle Valve | 0% | 20% |
| CAC Downstream Temperature | -20 deg C | 80 deg C |
| Ambient Air Temperature | -20 deg C | 80 deg C |
| Time engine running Normal | 10 seconds | |
| No Water Penetration Detected in Sensor | | |
| Engine Coolant Temperature at 1 second after key on | | 111 deg C |
| Difference in Barometric Pressure versus Pressure in Induction Volume | | 20 kPa |
| Engine Torque | 20 Nm | 200 Nm |
| Engine Speed | 500 rpm | 760 rpm |
| Turbocharger Position | 75% | |
| EGR Valve Position | | 5.1% |

| Typical Air Path Leakage Check Malfunction Thresholds: |
|---|
| If the ratio between modeled airflow and measured uncorrected airflow is greater than 1.18 or less than .76 a fault is detected and the appropriate P-code is set. |

| Mass Air Flow Sensor Plausibility Check Operation: | |
|---|---|
| DTCs | P1102 – Mass Air Flow Sensor In Range But Lower Than Expected<br>P1103 – Mass Air Flow Sensor In Range But Higher Than Expected |
| Monitor Execution | Continuous |
| Monitor Sequence | None. |
| Sensors OK | MAF (P0100, P0101, P0102), BP (P2228, P2229), EGRP (P0405, P0406, P0404, P0042E, P042F, P1335), |
| Typical Monitoring Duration | 10 seconds |

| Typical Mass Air Flow Sensor Plausibility Check Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Barometric Pressure | 75 kPa | 110 kPa |
| Engine Coolant Temperature | 70 deg C | 121 deg C |
| Ambient Air Temperature | -20 deg C | 80 deg C |
| Time engine running Normal | 5 seconds | |
| Key On | | |

| Typical Mass Air Flow Sensor Plausibility Check Malfunction Thresholds: |
|---|
| If Mass Air Flow is greater than the maximum AFS threshold map,, or less than the minimum AFS threshold map for 10 seconds, a fault is detected and a P-code is set. |

| Minimum AFS Threshold Map | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **RPM** | **400** | **600** | **1000** | **1500** | **2000** | **2500** | **3000** | **3500** |
| **Airflow** | **0** | **25** | **100** | **130** | **130** | **150** | **180** | **210** |

| Maximum AFS Threshold Map | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **RPM** | **600** | **750** | **1000** | **1500** | **2000** | **2500** | **3000** | **3500** |
| **Airflow** | **300** | **400** | **540** | **850** | **1100** | **1350** | **1550** | **1550** |

## Crankcase Ventilation Monitor

The 6.7L diesel engine has a crankcase ventilation separator mounted on the driver side rocker cover, with a tube connecting the separator to the fresh air inlet of the turbocharger. The tube on the separator side has a tamper proof collar installed and is plastic welded to the separator. On the fresh air inlet side, a hall effect sensor is present, to detect connection to the inlet casting assembly. The tube cannot be disconnected on the separator side, and if it is disconnected from the inlet casting, a P04DB code is set, as sensor output drops below a calibrated threshold. There are also circuit range checks, P04E2 and P04E3 to detect shorts to ground, or short to battery/disconnected sensor, respectively.

| Crankcase Ventilation Monitor | |
|---|---|
| DTCs | P04DB – Crankcase Ventilation System Disconnected<br>P04E2 – Crankcase Ventilation Hose Connection Sensor Circuit Low<br>P04E3 – Crankcase Ventilation Hose Connection Sensor Circuit High |
| Monitor Execution | Once per driving cycle – P04DB<br>Continuous – P04E2, P04E3 |
| Monitor Sequence | None |
| Sensors OK | P04DB - CVM (P04E2, P04E3) |
| Typical Monitoring Duration | 2 sec |

| Typical Crankcase Ventilation Monitor Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Coolant Temperature | 70C | 112 deg C |
| Ambient Temperature | -40C | 70 deg C |
| Battery Voltage | 9V | 16.25V |
| Key is on | | |

| Crankcase Ventilation Monitor Disconnection Check Malfunction Thresholds: |
|---|
| P04DB – voltage below 2500 mv for 2 seconds (all other entry conditions met, heals if voltage rises above 3000mv) |

| Crankcase Ventilation Monitor Circuit Check Malfunction Thresholds: |
|---|
| No minimum coolant, ambient temp entry conditions, continuous monitor:<br>P04E2 – voltage less than 1000 mv for 2 seconds<br>P01E3 – voltage greater than 4900 mv for 2 seconds |

## DEF Pressure Sensor

The DEF pressure control system uses the measured DEF pressure in a feedback control loop to achieve the desired DEF pressure. The DEF injection algorithm uses actual DEF pressure in its computation of DEF injector pulse width.

The DEF sensor is a gauge sensor. Its atmospheric reference hole is near the electrical connector. The DEF pressure sensor has a nominal range of 0 to 0.8 MPa (0 to 8 bar, 0 to 116 psi). This pressure range is above the maximum intended operating pressure of 0.5 MPa. The sensor voltage saturates at slightly above 0.5 and slightly below 4.5 volts.

DEF Pressure Sensor

DEF pressure is often a vacuum when the system purges after running. Vacuums cannot be measured by the DEF pressure gauge sensor as voltages will not be lower than 0.5 Volts.

| DEF Pressure Sensor Transfer Function | | |
|---|---|---|
| DEF Pump Pressure (PSI) = 29 * Voltage - 14.5 | | |
| **Volts** | **Pressure, MPa (gauge)** | **Pressure, psi (gauge)** |
| 5.00 | 0.8 | 116 |
| 4.50 | 0.8 | 116 |
| 3.50 | 0.6 | 87 |
| 2.50 | 0.4 | 58 |
| 1.00 | 0.1 | 14 |
| 0.500 | 0.0 | 0 |
| 0.250 | 0.0 | 0 |

Reductant Pressure Sensor Signal Range Check

| Reductant Pressure Sensor Open/Short Check Operation: | |
|---|---|
| DTCs | P204C - Reductant Pressure Sensor Circuit Low<br>P204D - Reductant Pressure Sensor Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | 0.4 seconds to register a malfunction |

| Typical Reductant Pressure Sensor Check Malfunction Thresholds: |
|---|
| Pressure sensor voltage < 0.20 volts or Pressure sensor voltage > 4.8 volts |

A reductant Pressure Sensor that is substantially in error results in a DEF system fault (over or under injection). If actual DEF pressure exceeds measured pressure, more DEF than that which would be expected is injected and vice versa. This error would show up in the long term adaption trim (DEF LTA).

## Reductant Pressure Plausibility Check before Start-up

If the hydraulic circuit of the DEF system (pump, pressure line, & injector) is completely empty, i.e. purge cycle was successfully completed during previous drive cycle, the DEF pressure is expected to read 0 kPa. Based on sensor tolerances the deviation from zero is limited to 30 kPa.

| Reductant Pressure Plausibility Check Operation: | |
|---|---|
| DTCs | P204B (SRC error for Reductant Pressure Sensor) |
| Monitor execution | Continuous, prior to pressure build-up |
| Monitor Sequence | P204B is inhibited by active P204C or P204D codes |
| Sensors/Actuators OK | none |
| Monitoring Duration | 0.6 seconds to register a malfunction |

| Typical Reductant Pressure Plausibility Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| DEF pump and line not primed | | 0 |
| DEF system not pressurized | | |
| DEF tank and pump not frozen | True | |

| Typical Reductant Pressure Plausibility Check Malfunction Thresholds: |
|---|
| P204B: > 30 kPa for 0.6 sec |

## DEF Pressure Build-up Check at Start-up

After the fill cycle is completed, the injector is closed and the system pressure is expected to rise.

| Reductant Pressure Functional Check: | |
|---|---|
| DTCs | P20E8 – Reductant Pressure too Low |
| Monitor execution | Once during pressure build-up |
| Monitor Sequence | P20E8 is inhibited by active P204B, P204C or P204D codes |
| Sensors/Actuators OK | Reductant pressure sensor, Reductant pump motor, injector |
| Monitoring Duration | 1 event (3 times 15 seconds) |

| Typical Reductant Pressure Plausibility Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| DEF pump and line not primed | | 0 |
| DEF system not pressurized | | |
| DEF tank not frozen | True | |

| Typical Reductant Pressure Plausibility Check Malfunction Thresholds: |
|---|
| P204B: pressure does not exceed 350 kPa after 45 sec with spinning pump |

## DEF System Pressure Control

DEF pressure is maintained via feedback knowledge of sensed pressure.

A set point pressure is determined by engine operating conditions (500 kPa over exhaust backpressure). If a pressure increase is desired, the urea pump motor speed is increased by increasing the PWM output. Pressure decreases are analogous; as the system has a backflow throttle, pressure will decrease to 0 unless the pump motor in run continuously.

| Reductant Pressure Control (Normal) Functional Check Operation: | |
|---|---|
| DTCs | P20E8 - Reductant Pressure Too Low<br>P20E9 - Reductant Pressure Too High |
| Monitor execution | Continuous |
| Monitor Sequence | P20E8 & P20E9 are inhibited by active P204b, P204C or P204D codes |
| Sensors/Actuators OK | reductant pump pressure sensor, reductant pump motor, reductant injector |
| Monitoring Duration | > 10 sec (resp. > 60 sec, see below) |

| Typical Reductant Pressure Control (Normal) Functional Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| DEF system pressure in closed loop control previously | True | |

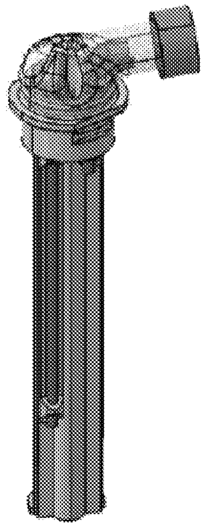
| Typical Reductant Pressure Control (Normal) Functional Check Malfunction Thresholds: |
|---|
| P20E8: < 400 kPa for 60 sec respectively < 300 kPa for 10 sec<br>P20E9: > 650 kPa for 10 sec respectively > 790 kPa for 1 sec |

## Reductant Tank Level Sensor

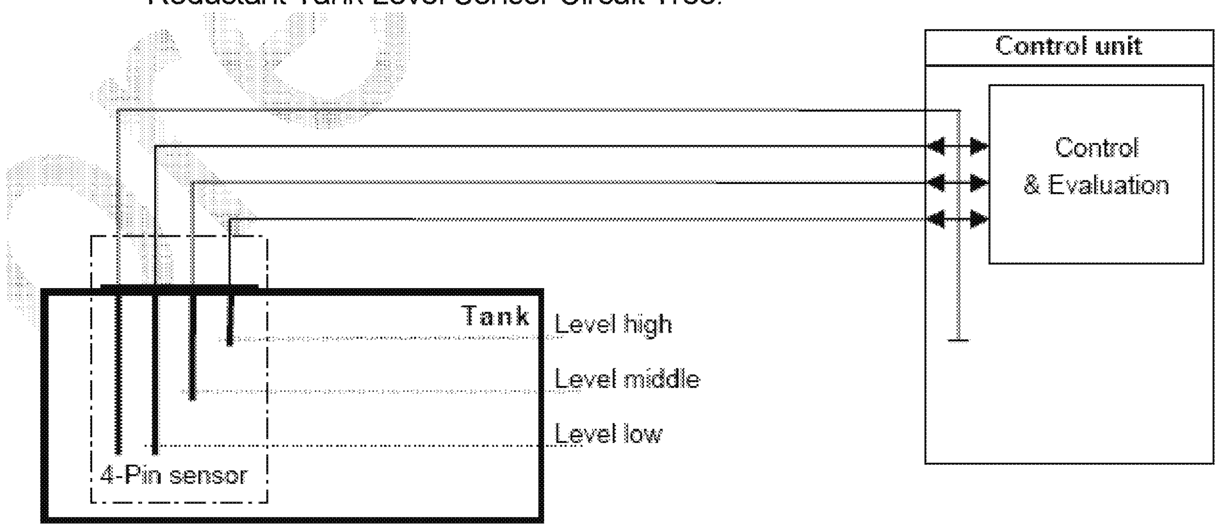
The task of the discrete level sensor is to measure the tank level at 3 different heights. The determination of a reductant level is limited to liquid reductant. Frozen reductant cannot be detected. The measured level will be used to update the calculation of remaining quantity in the reductant tank.

The level sensor consists of four high-grade stainless steel pins. The length of each pin defines the tank level (height) which is to be checked. Only three pins can be used for level evaluation. The fourth pin is used as ground pin. Due to the electrical conductivity of Urea the level sensor will determine whether the tank level is above or below the respective level sensor position. This information will be directly evaluated by the ECU.

Reductant Tank Level Sensor:



Reductant Tank Level Sensor Circuit Tree:



Reductant Tank Level Sensor Circuit Checks

| Reductant Tank Level Sensor Open/Short Check Operation: | |
|---|---|
| DTCs | P203D - Reductant Level Sensor "A" Circuit High (SRC max – pin 1 & SCB)<br>P21AB - Reductant Level Sensor "B" Circuit High (SRC max – pin 2)<br>P21B0 - Reductant Level Sensor "C" Circuit High (SRC max – pin 3)<br>P203A - Reductant Level Sensor Circuit (OL)<br>P203C - Reductant Level Sensor Circuit Low (SCG) |
| Monitor execution | Continuous, every 4 seconds (3x 1 sec to read from each individual pin, 1 sec for diagnosis) |
| Monitor Sequence | None |
| Sensors OK | None |
| Monitoring Duration | 0.5 seconds to register a malfunction within diagnostic mode |

| Typical Tank Level Sensor Open/Short Check Malfunction Thresholds: |
|---|
| P203D, P21AB & P21B0: voltage > 3.24 Volts (Signal range check max. for pin 1, 2 & 3)<br>P203D: no calibration thresholds available, SCB fault information is sent directly from power stage<br>P203C: no calibration thresholds available, SCG fault information is sent directly from power stage<br>P203A: no calibration thresholds available, OL fault information is sent directly from power stage |

The Reductant Tank Level Sensor and the Reductant Tank Temperature Sensor share the same ground wire. Therefore an open load or short circuit to battery on the ground wire (reference pin) will set codes for both sensors.

## Reductant Tank Level Sensor Plausibility Check

If a certain level pin is covered by liquid all pins below this level should be covered as well and send the same information. If this is not the case, an error flag will be set.

| Reductant Tank Level Sensor Plausibility Check Operation: | |
|---|---|
| DTCs | P203B – Reductant Level Sensor Circuit Range/Performance |
| Monitor execution | Continuous |
| Monitor Sequence | none |
| Sensors/Actuators OK | Reductant Level sensor signal range checks |
| Monitoring Duration | 60 seconds to register a malfunction |

| Typical Reductant Tank Level Sensor Plausibility Check Malfunction Thresholds: |
|---|
| no calibration thresholds available |

## Reductant Tank Temperature Sensor

The Reductant Tank Temperature sensor is mounted internal to the Reductant Tank Level Sensor. It is used to control the activation of the Reductant Tank Heater as well as an enabler to the Level Sensor (which cannot read level when the reductant is frozen).

**Transfer Function**

| Temperature Deg C | Resistance (Ohms) |
|---|---|
| | |
| -40 | 336 |
| -30 | 177 |
| -20 | 97 |
| -10 | 55 |
| 0 | 32 |
| 10 | 20 |
| 20 | 12 |
| 30 | 8 |
| 40 | 5.3 |
| 50 | 3.6 |
| 60 | 2.5 |
| 70 | 1.8 |
| 80 | 1.2 |

| Reductant Tank Temperature Circuit Range Check | |
|---|---|
| DTCs | P205C Reductant Tank Temperature Sensor Circuit Low<br>P205D Reductant Tank Temperature Sensor Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | 0.4 seconds to register a malfunction |

| Typical Intake Reductant Tank Temperature Circuit Range Check Malfunction Thresholds |
|---|
| P205C: voltage < 0.097 Volts<br>P205D: voltage > 3.201 Volts |

## Plausibility Check

On every cold start of the vehicle (min. soak time > 6 hours) the value of the tank temperature sensor is expected to be close to the environmental temperature.

| Reductant Tank Temperature Plausibility Check | |
|---|---|
| DTCs | P2043 Reductant Temperature Sensor Circuit Range/Performance |
| Monitor execution | At cold start conditions / extended soak time |
| Monitor Sequence | P2043 is inhibited by active P205C or P205D codes |
| Sensors OK | Ambient temp sensor, exhaust gas temp. sensor upstream SCR catalyst, engine coolant temperature sensor (downstream) |
| Monitoring Duration | counts intermittent events per trip |

| Typical Reductant Tank Temperature Plausibility Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine off timer | 6 hours | |
| Reductant Tank Fluid level | 10 % | 100 % |
| Max (ambient temp, SCR catalyst temp., engine coolant temp.)<br>-<br>Min (ambient temp., SCR catalyst temp., engine coolant temp.) | | 10 deg C |

| Typical Reductant Tank Temperature Plausibility Check Malfunction Thresholds |
|---|
| Reductant tank temperature – ambient temperature > 20 deg C or < -20 deg C |

## Exhaust Gas Temperature Sensor Rationality Test

Each EGT Sensor is checked continuously for proper circuit continuity and out of range high values. In addition, a rationality test is performed once every drive cycle, after a soak of 6 hours or greater. The rationality test consists of two components, the first being a comparison against modeled values, and the second being a key-on 4-way temperature sensor comparison. At key-on, a temperature sample is taken of each of the following sensors: Exhaust Gas Temperature (EGT11), Exhaust Gas Temperature (EGT12), Exhaust Gas Temperature (EGT13), and Exhaust Gas Temperature (EGT14). Once the engine starts and a cold start has been confirmed, the model comparison tests begin. The model comparison tests ensure that each sensor correlates with an expected modeled value, and a fault is set if the difference is significant (greater than upper threshold or less than lower threshold) and persistent. In the second rationality test, the temperature samples from 4 EGTs at key-on are compared against each other, and the temperature differences are compared against a threshold. One sensor must fail key-on plausibility with three other sensors to set a fault. If two or more sensors fail plausibility with the remaining sensors,, then appropriate faults pointing to the faulty EGTs are set. The first (model versus sensor) rationality tests rely on entry conditions that include engine on time, minimum modeled temperature, minimum engine coolant temperature, and minimum engine torque. Once the entry conditions have been met, the model comparisons continue for several minutes to ensure a robust detection. The modeled value for EGT11 is based on Modeled Turbo Temperatures. The modeled value for EGT12 is based on EGT11. The modeled value for EGT13 is based on EGT12. The modeled value for EGT14 is based on EGT13. In addition, both plausibility tests depend on minimum engine soak time of 6 hours or more.

| Exhaust Gas Temperature (EGT) Sensor Circuit Check: | |
|---|---|
| DTCs | P0545 – Exhaust Gas Temperature Circuit Low (Sensor 1)<br>P0546 – Exhaust Gas Temperature Sensor Circuit High (Sensor 1)<br>P2478 – Exhaust Gas Temperature Out Of Range (Sensor 1)<br>P2032 – Exhaust Gas Temperature Circuit Low (Sensor 2)<br>P2033 – Exhaust Gas Temperature Sensor Circuit High (Sensor 2)<br>P2479 – Exhaust Gas Temperature Out Of Range (Sensor 2)<br>P242C – Exhaust Gas Temperature Circuit Low (Sensor 3)<br>P242D – Exhaust Gas Temperature Sensor Circuit High (Sensor 3)<br>P247A – Exhaust Gas Temperature Out Of Range (Sensor 3)<br>P2470 – Exhaust Gas Temperature Circuit Low (Sensor 4)<br>P2471 – Exhaust Gas Temperature Sensor Circuit High (Sensor 4)<br>P247B – Exhaust Gas Temperature Out Of Range (Sensor 4) |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | 2 sec. |

| Typical Exhaust Gas Temperature Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 9 V | 16.25 V |
| Key On | | |

| Typical Exhaust Gas Temperature Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < 0.10 volts or voltage > 4.90 volts<br>Out Of Range test is based on Engineering Units and is high-side only. The Out Of Range Threshold is typically set to 1150 deg C. Transfer function of the sensors does not allow for unique circuit range and engineering range thresholds on the low-side. |

The Exhaust Gas Temperature Sensor is a PTC Thermistor that provides an analog output voltage proportional to the exhaust gas temperature. This EGT sensor is capable of being used anywhere in the exhaust gas stream. Some possible applications are listed below:

| | |
|---|---|
| EGT | Exhaust Gas Temp |
| EGR_CIT | EGR Cooler Inlet Exhaust Gas Temp |
| EGR_COT | EGR Cooler Outlet Exhaust Gas Temp |
| DPF_IN | Diesel Particualte Filter Inlet Exhaust Gas Temp |
| DPF_OUT | Diesel Particulate Filter Outlet Exhaust Gas Temp |
| SCR_IN | SCR Inlet Exhaust Gas Temp |
| SCR_OUT | SCR Outlet Exhaust Gas Temp |

| EGT Sensor Transfer Function | | | |
|---|---|---|---|
| Vout = (Vref * R sensor) / (1K + R sensor)<br>Response Time: 1 time constant = 15 sec for 300 deg C step @ 10m/sec gas flow | | | |
| Volts | A/D Counts in PCM | Ohms | Temperature, deg C |
| 0.10 | | short circuit | n/a |
| 0.71 | | 171 | -40 |
| 0.82 | | 202 | 0 |
| 1.06 | | 277 | 100 |
| 1.27 | | 350 | 200 |
| 1.45 | | 421 | 300 |
| 1.61 | | 490 | 400 |
| 1.75 | | 556 | 500 |
| 1.88 | | 619 | 600 |
| 1.99 | | 691 | 700 |
| 2.09 | | 740 | 800 |
| 2.14 | | 768 | 850 |
| 2.34 | | | 1100 |
| 4.90 | | open circuit | n/a |

| Exhaust Gas Temperature Rationality Check | |
|---|---|
| DTCs | **Sensor vs. Model Plausibility**<br>P0544 – Exhaust Gas Temperature Sensor Circuit (Sensor 1)<br>P2031 – Exhaust Gas Temperature Sensor Circuit (Sensor 2)<br>P242A – Exhaust Gas Temperature Sensor Circuit (Sensor 3)<br>P246E – Exhaust Gas Temperature Sensor Circuit (Sensor 4)<br>**Sensor to Sensor Plausibility**<br>P2080 - Exhaust Gas Temperature Sensor Circuit Range/Performance (Bank 1, Sensor 1)<br>P2084 - Exhaust Gas Temperature Sensor Circuit Range/Performance (Bank 1, Sensor 2)<br>P242B - Exhaust Gas Temperature Sensor Circuit Range/Performance (Bank 1, Sensor 3)<br>P246F - Exhaust Gas Temperature Sensor Circuit Range/Performance (Bank 1, Sensor 4) |
| Monitor Execution | Once per driving cycle. |
| Monitor Sequence | Correlation Test completes after the Model Comparison Tests once the cold start is detected. |
| Sensors OK | |
| Typical Monitoring Duration | Model Comparison Test Monitor Duration is 200 to 400 seconds. |

| Typical Exhaust Gas Temperature Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine Off Time | 6 hrs | N/A |
| Coolant Temp | 68 deg C | N/A |
| Engine Run Time | 120 seconds | |
| Modeled Sensor Temp | 120 deg C for EGT11<br>100 deg C for EGT12<br>95 deg C for EGT13<br>90 deg C for EGT14 | |
| Engine Torque | 100 Nm | |

| Typical Exhaust Gas Temperature Rationality Check Thresholds: | |
|---|---|
| Each EGT Rationality is confirmed against 3 other sensors (absolute temperature difference thresholds): | |
| Key-On Comparison Threshold | 50 deg C |
| Modeled Comparison Threshold | 75 and -180 deg C for EGT11, ±80 deg C for EGT12, ±60 deg C for EGT13, ±60 deg C for EGT14 |
| Modeled Comparison Duration | Comparison Test will run for 200 to 400 seconds. Fault must persist for 20 seconds for robust detection. |

| Diesel Particulate  Filter Over Temperature Check: | |
|---|---|
| DTCs | P200C– Diesel Particulate Filter Over Temperature (Bank1)<br>P200E – Catalyst System Over Temperature (Bank 1) |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | 3 sec. |
| Thresholds | P200C – Pre DPF > 830C or Post DPF > 950C or Post DPF Temp Sensor Circuit failure<br>P200E - The conditions for P200C have been met for 3 seconds and vehicle speed is less than 1 km/hr |

## Diesel Particulate Filter Pressure Sensor Rationality Test

For 2013 P473 program, a delta pressure sensor (DPS) is added at the pre DPF location, and it continuously monitors the pressure drop across the DPF for both chassis cert and dyno cert vehicles. Both the DPFP Sensor and DPS are checked continuously for proper circuit continuity, stuck sensor and pressure sensor plausibility. The rationality test compares the measured pressure by the DPFP (gauge pressure) and the inferred pressure from the delta pressure sensor (which is the measured pressure drop across DPF plus the modeled pressure drop after the DPF up to the cold end). The fault is set when this difference is above or below the calibrated thresholds.

| Diesel Particulate Filter Pressure (DPFP) Sensor Circuit Check: | |
|---|---|
| DTCs | P2454 – DPFP Sensor Circuit Low<br>P2455 – DPFP Sensor Circuit High |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | 2 sec. |

| Typical Diesel Particulate Filter Pressure Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 9 V | 16.25 V |
| Key On | | |

| Typical Diesel Particulate Filter Pressure Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < 0.10 volts or voltage > 4.90 volts |

The DPFP sensor is a single port gauge sensor that provides an analog output voltage that is proportional to pressure and is typically used before and after a DPF (Diesel Particulate Filter) to monitor the differential pressure.

| DPFP Sensor Transfer Function | | |
|---|---|---|
| DPFP volts = 0.082 * kPaG Delta Pressure) + 0.45 | | |
| Volts | A/D Counts in PCM | Delta Pressure, kPa Gauge |
| 0.10 | 20 | -4.3 |
| 0.45 | 92 | 0 |
| 1.27 | 260 | 10 |
| 2.09 | 428 | 20 |
| 2.91 | 595 | 30 |
| 3.73 | 763 | 40 |
| 4.55 | 931 | 50 |
| 4.90 | 1003 | 54.3 |

| Diesel Particulate Filter Pressure Sensor Rationality Check | |
|---|---|
| DTCs | P246D – Particulate Filter Pressure Sensor "A"/"B" Correlation |
| Monitor Execution | Continuous. |
| Monitor Sequence | None. |
| Sensors OK | |
| Typical Monitoring Duration | 2 seconds. |

| Typical Diesel Particulate Filter Pressure Sensor Rationality Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Environmental Pressure | 745 hPa | |
| Environmental Temperature | -40 Deg C | |
| Coolant Temperature | 70 Deg C | |
| Pre DPF Temperature | 125 Deg C | 425 Deg C |
| Exhaust Flow | 200 kg/hr | 600 kg/hr |

| Typical Diesel Particulate Filter Pressure Sensor Rationality Check Thresholds: |
|---|
| Absolute difference of greater than 1.5 kPa |

## Diesel Particulate Filter Pressure Offset Test

The DPFP Sensor is checked during after-run conditions (period where the key is turned off, however the ECU is still powered), to verify that the sensor has not drifted from the ambient with no exhaust flow. This test is performed by comparing the sensed pressure to a threshold (due the gauge sensor, this value should be 0)

| Diesel Particulate Filter Pressure Sensor Offset Check | |
|---|---|
| DTCs | P2452 – DPFP Sensor Circuit "A" |
| Monitor Execution | Afterrun |
| Monitor Sequence | None. |
| Sensors OK | DPFP Sensor |
| Typical Monitoring Duration | 1 second. |

| Typical Diesel Particulate Filter Pressure Sensor Offset Check Thresholds: |
|---|
| Exhaust Pressure Sensor value > 1 kPa |

The DPS is a dual port delta pressure sensor that provides an analog output voltage that is proportional to pressure drop and is typically used before and after a DPF (Diesel Particulate Filter) to monitor the differential pressure.

| Diesel Particulate Filter Delta Pressure (DPS) Sensor Circuit Check: | |
|---|---|
| DTCs | P2460 – DPS Sensor Circuit Low<br>P2461 – DPS Sensor Circuit High |
| Monitor Execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | Not applicable |
| Typical Monitoring Duration | 2 sec. |

| Typical Diesel Particulate Filter Delta Pressure Sensor Circuit Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery Voltage | 9 V | 16.25 V |
| Key On | | |

| Typical Diesel Particulate Filter Delta Pressure Sensor Circuit Check Malfunction Thresholds: |
|---|
| Voltage < .10 volts or voltage > 4.90 volts |

| DPS Sensor Transfer Function | | |
|---|---|---|
| DPFP volts = 0.082 * kPaG Delta Pressure) + 0.45 | | |
| Volts | A/D Counts in PCM | Delta Pressure, kPa Gauge |
| 0.5 | 20 | 0.0 |
| 1.0 | 92 | 4.4 |
| 1.6 | 260 | 9.6 |
| 2.0 | 428 | 13.1 |
| 2.6 | 595 | 18.4 |
| 3.0 | 763 | 21.9 |
| 3.6 | 931 | 27.1 |
| 4.0 | 1003 | 30.6 |
| 4.6 | | 35.9 |
| 4.8 | | 37.6 |

## Diesel Particulate Filter Pressure Offset Test (DPS)

The DPS is checked during after-run conditions (period where the key is turned off, however the ECU is still powered), to verify that the sensor has not drifted from the ambient with no exhaust flow. This test is performed by comparing the sensed pressure to a threshold (due the delta pressure across DPF should be 0)

| Diesel Particulate Filter Delta Pressure Sensor Offset Check | |
|---|---|
| DTCs | P245E – DPS Sensor Circuit "B" |
| Monitor Execution | Afterrun |
| Monitor Sequence | None. |
| Sensors OK | DPS Sensor |
| Typical Monitoring Duration | 1 second. |

| Typical Diesel Particulate Filter Delta Pressure Sensor Offset Check Thresholds: |
|---|
| Exhaust Pressure Sensor value > 1 kPa |

## Engine Outputs

### EGR Valve Actuator Signal Range Check

The diagnostics for the circuit range check on the pwm signal to the EGR valve are internal to the h-bridge PWM power-stage. Open load, short-circuit to ground, and short-circuit to battery are detected on both the positive and negative control lines to the actuator.

| EGR Valve Actuator Open Load (P0403) Check Operation: | |
|---|---|
| DTCs | P0403 – Exhaust Gas Recirculation "A" Control Circuit |
| Monitor execution | At start; when Power-stage is OFF. |
| Monitor Sequence | None |
| Monitoring Duration | 0.35 seconds to register a malfunction |

| EGR Valve Actuator Short Circuit (P0489/P0490) Check Operation: | |
|---|---|
| DTCs | P0489 – EGR "A Control Circuit Low,<br>P0490 – EGR "A" Control Circuit High |
| Monitor execution | Continuous; when Power-stage ON |
| Monitor Sequence | None |
| Monitoring Duration | 0.35 seconds to register a malfunction |

### EGR Valve Actuator Jammed Detection

The EGR valve has a component level diagnostic to make sure that the valve is not stuck or sticking in a manner such that it cannot reach the desired position. The monitor runs if a jammed valve is not already detected, position control is in closed-loop control, and adaptive learning is not active. A minimum engine speed is used as an entry condition.

If the position governor deviation is above a maximum calibrated threshold then counter starts to count up for the detection of a permanent positive control fault. If the counter reaches a calibrated threshold then a jammed valve malfunction is detected. Similarly, if the position governor deviation is below a minimum calibrated threshold then a second counter starts to count up for the detection of permanent negative control deviation fault. If the counter reaches a calibration threshold then a jammed valve is detected.

| EGR Valve Jammed Check Operation: | |
|---|---|
| DTCs | P042E – Exhaust Gas Recirculation "A" Control Stuck Open |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Actuator Jammed Valve Entry Conditions: | | |
|---|---|---|
| **Entry Condition** | **Minimum** | **Maximum** |
| Governor Active (closed-loop position control) | | |
| Adaptive Learning Not Active | | |
| Jammed Valve Fault Not Present on Actuator | | |
| RPM | 700 rpm | |

| Typical EGR Valve Jammed Check (P042E) Malfunction Thresholds: |
|---|
| EGRVlv_rGovDvt > 8.60 or EGRVlv_rGovDvt < -8.60 |

## Throttle Valve Actuator Signal Range Check

The diagnostics for the circuit range check on the pwm signal to the throttle valve are internal to the h-bridge PWM power-stage. Open load, short-circuit to ground, and short-circuit to battery are detected on both the positive and negative control lines to the actuator.

| Throttle Valve Actuator Open-Load (P02E0) Check Operation: | |
|---|---|
| DTCs | P02E0 – Diesel Intake Air Flow Control Circuit / Open |
| Monitor execution | At start; when Power-stage is OFF. |
| Monitor Sequence | None |
| Monitoring Duration | 0.2 seconds to register a malfunction |

| Throttle Valve Actuator Short Circuit (P02E2/P02E3) Check Operation: | |
|---|---|
| DTCs | P02E2- Diesel Intake Air Flow Control Circuit Low;<br>P02E3- Diesel Intake Air Flow Control Circuit High |
| Monitor execution | Continuous; when power stage ON |
| Monitor Sequence | None |
| Monitoring Duration | 0.2 seconds to register a malfunction. |

## Throttle Valve Actuator Jammed Detection

The throttle valve has a component level diagnostic to make sure that the valve is not stuck or sticking in a manner such that it cannot reach the desired position. The monitor runs if a jammed valve is not already detected, position control is in closed-loop control, and adaptive learning is not active.

If the position governor deviation is above a maximum calibrated threshold then counter starts to count up for the detection of a permanent positive control fault. . If the counter reaches a calibrated threshold then a jammed valve malfunction is detected. Similarly, if the position governor deviation is below a minimum calibrated threshold then a second counter starts to count up for the detection of permanent negative control deviation fault. If the counter reaches a calibration threshold then a jammed valve is detected.

A special case exists if the throttle is jammed in the closed position during crank. When the throttle is jammed in the closed position the engine is unable to start. The counter counts up more quickly to allow for the fault to be detected before the crank ends.

| Actuator Jammed Valve Check Operation: | |
|---|---|
| DTCs | P02E1 – Diesel Intake Air Flow Control Performance, |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 5 seconds to register a fault during normal operation. 1 second to register a malfunction during crank. |

| Typical Actuator Jammed Valve Entry Conditions: |
|---|
| **Entry Condition** |
| Governor Active (closed-loop position control) |
| Adaptive Learning Not Active |
| Jammed Valve Fault Not Present on Actuator |

| Typical Throttle Jammed Valve Check (P02E1) Malfunction Thresholds: |
|---|
| Position Governor Deviation > 12.5% or <-12.5 % |

## ECB Valve Actuator Signal Range Check

| ECB Actuator Open-Load Check Operation: | |
|---|---|
| DTCs | P2425 - Exhaust Gas Recirculation Cooling Valve Control Circuit Open Load |
| Monitor execution | Continuous; |
| Monitor Sequence | None |
| Monitoring Duration | 2 seconds to register a malfunction |

| ECB Actuator Short-Circuit (P2426/P2427) Check Operation: | |
|---|---|
| DTCs | P2426- Exhaust Gas Recirculation Cooling Valve Control Circuit Low,<br>P2427- Exhaust Gas Recirculation Cooling Valve Control Circuit High |
| Monitor execution | Continuous; |
| Monitor Sequence | None |
| Monitoring Duration | 2 seconds to register a malfunction. |

## Urea System Pressure Control

Urea pressure is maintained via feedback knowledge of sensed pressure.

A set point pressure is determined by engine operating conditions (500 kPa over exhaust backpressure). If a pressure increase is desired, the urea pump motor speed is increased by increasing the PWM output. Pressure decreases are analogous; as the system has a backflow throttle, pressure will decrease to 0 unless the pump motor in run continuously.

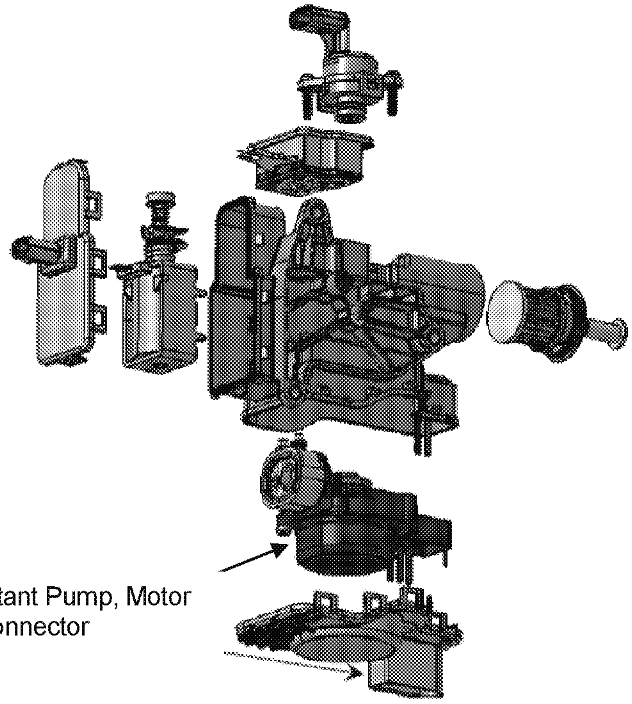
| Urea Pump Pressure Control (Normal) Functional Check Operation: | |
|---|---|
| DTCs | P20E8 (Reductant Pressure Too Low)<br>P20E9 (Reductant Pressure Too High) |
| Monitor execution | continuous |
| Monitor Sequence | P204C and P204D must complete before setting P20E8 or P20E9 |
| Sensors/Actuators OK | Urea pump pressure sensor, Urea pump motor, Urea injector |
| Monitoring Duration | > 60 sec |

| Typical Urea Pump Pressure Control (Normal) Functional Check Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Reductant system pressurized and ready to inject | | |

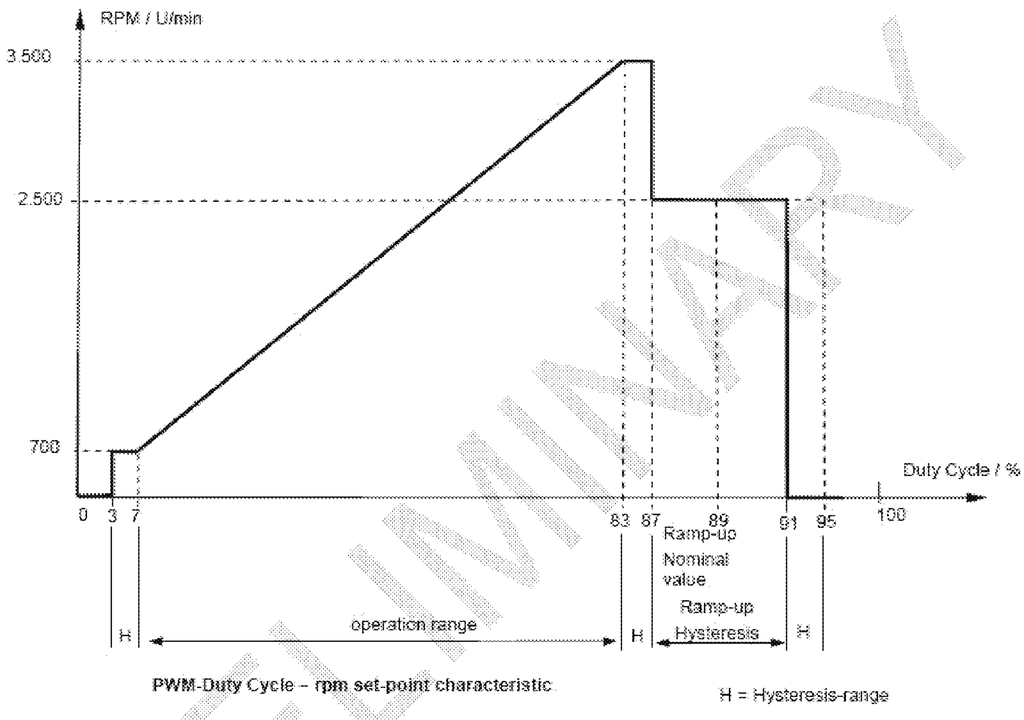
| Typical Urea Pump Pressure Control (Normal) Functional Check Malfunction Thresholds: |
|---|
| P20E8: < 350 kPa<br>P20E9: > 700 kPa |

## Reductant Pump Motor

The Reductant Pump is driven by a brushless DC electric 12 volt motor. The pump is a positive displacement diaphragm design connected to the motor by a connecting rod and an eccentric on the motor shaft.




Reductant Pump Motor speed is controlled by a PWM driver in the engine ECU. Increasing the duty cycle of the PWM increases the Pump Motor speed. PWM duty cycles between 87 and 95 are reserved for diagnostics.



**Reductant Pump Motor Circuit Checks**

| Reductant Pump Motor Open/Short Check Operation: | |
|---|---|
| DTCs | P208A – Reductant Pump Control Circuit Open<br>P208C – Reductant Pump Control Circuit Low<br>P208D – Reductant Pump Control Circuit High |
| Monitor execution | Continuous – Open and Low with driver off / High with driver on |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | Circuit Open / Low: 8 seconds to register a malfunction<br>Circuit High: 2 seconds to register a malfunction |

| Typical Reductant Motor Check Malfunction Thresholds: |
|---|
| No calibration thresholds available, fault information is sent directly from power stage.<br>P208A - Reductant Pump Control Open Circuit > 5.80 volts<br>P208C - Reductant Pump Control Circuit Low < 3.50 volts<br>P208D - Reductant Pump Control Circuit High > 2.2 amps |

**Reductant Pump Motor Functional Check**

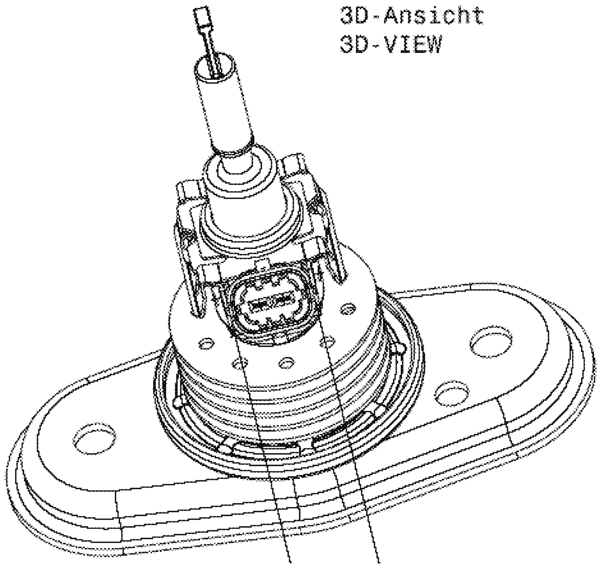
The functional check monitors the Pump Motor Speed Deviation. This test is run if the commanded pump speed is within normal operating range, i.e. duty cycle 6.5 to 80 %. In this test if the internal RPM measurement of the Reductant Pump Motor speed is not matching the commanded speed within a certain percentage, a fault is detected and the system is shut down for this key cycle.

| Reductant Pump Motor Control (Normal) Functional Check Operation: | |
|---|---|
| DTCs | P208B – Reductant Pump Control Range/Performance |
| Monitor execution | continuous |
| Monitor Sequence | P208A , P208C, P208D must complete |
| Sensors/Actuators OK | Reductant pump pressure sensor, Reductant injector |
| Monitoring Duration | 5 sec for fault detection |

| Typical Reductant Pump Motor Control (Normal) Functional Check Malfunction Thresholds: |
|---|
| P208B: > 300 RPM error |

## Reductant Dosing Valve (Injector)

The reductant dosing valve is used to meter and atomize the reductant liquid before it is mixed with the exhaust gas. Normal operating frequency is between 3 Hz and .3 Hz. The cooling body contains heat sink fins to keep the injector and reductant below the boiling point. If the sensed temperature is nearing the maximum temperature threshold, reductant spray will be increased in quantity to actively cool the valve.




**Reductant Dosing Valve Circuit Checks**

| Reductant Dosing Valve Circuit Check Operation: | |
|---|---|
| DTCs | P2047 – Reductant Injection Valve Circuit / Open (Bank 1 Unit 1)<br>P2048 – Reductant Injection Valve Circuit Low (Bank 1 Unit 1)<br>P2049 – Reductant Injection Valve Circuit High (Bank 1 Unit 1) |
| Monitor execution | Continuous |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | 2 seconds to register a malfunction |

| Typical Reductant Dosing Valve Circuit Check Malfunction Thresholds: |
|---|
| No calibration thresholds available, fault information is sent directly from power stage |
| P2047 – Reductant Injection Valve Circuit / Open (Bank 1 Unit 1) - >5.80 volts |
| P2048 – Reductant Injection Valve Circuit Low (Bank 1 Unit 1) - < 3.2 volts HS, < 3.5 volts LS |
| P2049 – Reductant Injection Valve Circuit High (Bank 1 Unit 1) - > .4 volts HS, >2.2 amps LS |

**Plausibility Check for Pump Motor Duty Cycle (Leakage / Clogging)**

The Pump Motor Duty Cycle is monitored depending on Urea dosing request.

| Plausibility Check for Reductant Flow: | |
|---|---|
| DTCs | P202D - Reductant Leakage<br>P218F - Reductant System Performance |
| Monitor execution | continuous |
| Monitor Sequence | P208A , P208C, P208D must complete |
| Sensors/Actuators OK | Urea pump pressure sensor, Urea injector |
| Monitoring Duration | 2 sec for fault detection – 3 events per drive cycle |

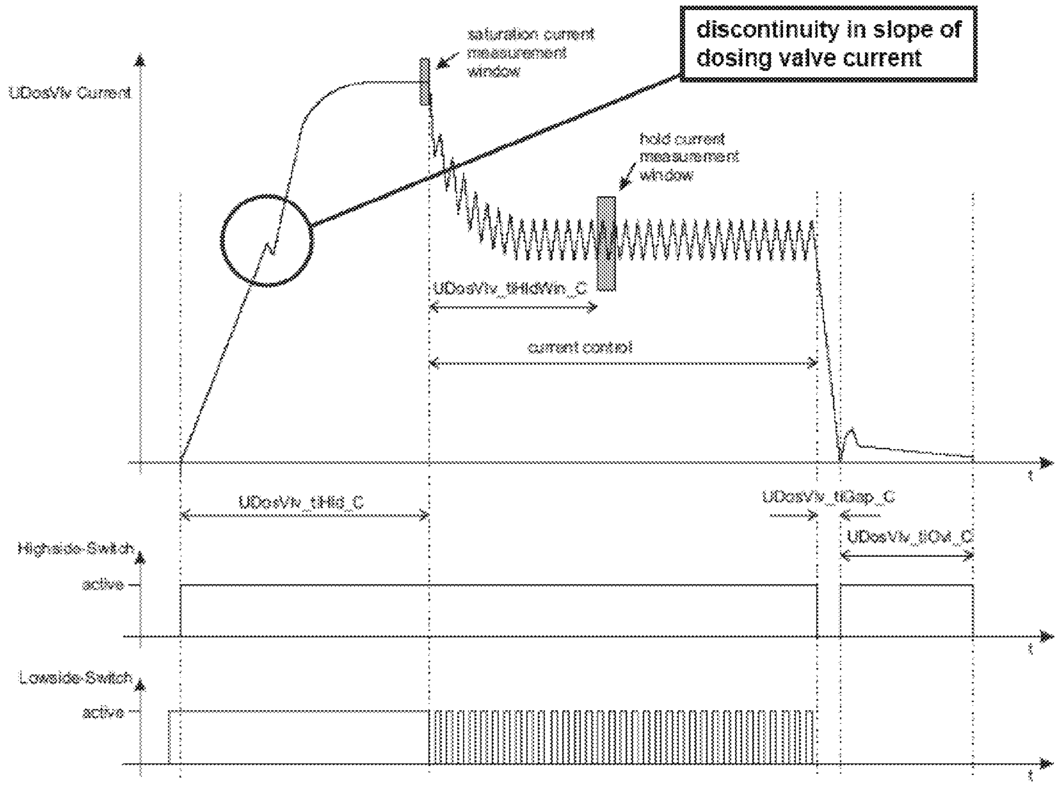
| Typical Plausibility Check for Pump Motor Duty Cycle Entry Conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| CoSCR_stSub | Metering control | Metering control |

| Typical Plausibility Check for Pump Motor Duty Cycle Malfunction Thresholds: |
|---|
| P202D (Reductant Leakage):<br>- no dosing: pump duty cycle > 50 %<br>- dosing: pump duty cycle increase > 50 %<br>P218F (Reductant no flow):<br>- no dosing: pump duty cycle < 6.75 %<br>- dosing: pump duty cycle increase < 5 % (dosing rate > 200 mg/sec) |

**Reductant Dosing Valve Functional Check**

The functional check monitors the movement of the injector needle. When the injector needle reaches its upper position (injector open, begin of injection period) a discontinuity in the slope of the dosing valve current occurs.

This functional check monitors the presence of this discontinuity. If it does not occur the injector is either stuck open or stuck closed. In both case the system cannot be operated and will be shut down.

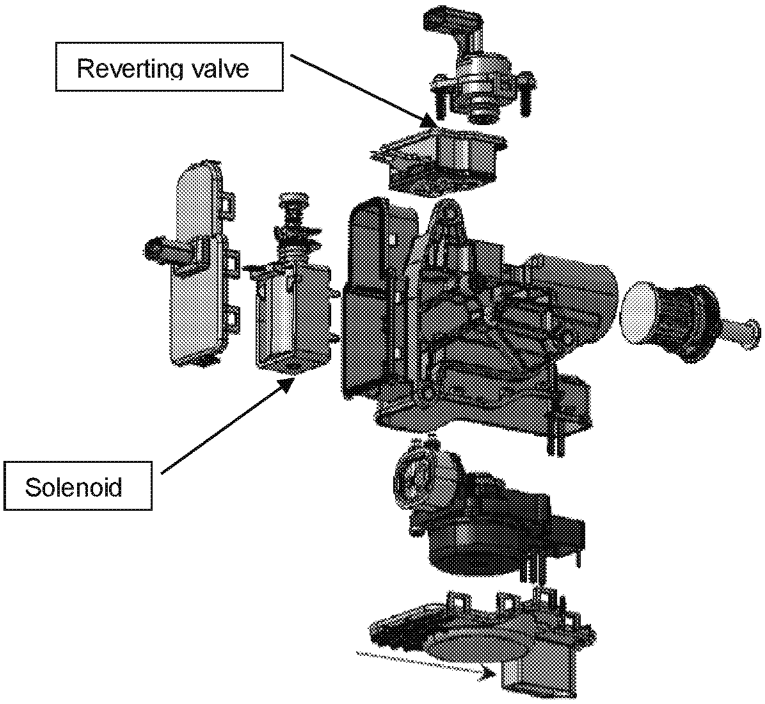



| Reductant Injection Functional Check Operation: | |
|---|---|
| DTCs | P208E - Reductant Injection Valve Stuck Closed (Bank 1 Unit 1) |
| Monitor execution | Once per injection stroke |
| Monitor Sequence | P208E is inhibited by active P2047, P2048 or P2049 |
| Sensors/Actuators OK | Reductant pump motor, Reductant pressure sensor |
| Monitoring Duration | 50 injection strokes for fault detection |

| Typical Reductant Injection Functional Check Malfunction Thresholds: |
|---|
| No calibration thresholds available, fault information is sent directly from power stage |

## Reverting Valve

In order to reverse the Reductant flow direction (for line purge) a 4-2-way valve (reverting valve) needs to be switched. The valve is switched by a solenoid.




**Reverting Valve Circuit Checks**

| Reverting Valve Circuit Check Operation: | |
|---|---|
| DTCs | P20A0 – Reductant Purge Control Valve Circuit / Open<br>P20A3 – Reductant Purge Control Valve Circuit High<br>P20A2 – Reductant Purge Control Valve Circuit Low |
| Monitor execution | Continuous – Open and Low with driver off / High with driver on |
| Monitor Sequence | none |
| Sensors OK | none |
| MonitoringDuration | 2 seconds to register a malfunction |

| Typical Reverting Valve Circuit Check Malfunction Thresholds: |
|---|
| No calibration thresholds available, fault information is sent directly from power stage |

**Reverting Valve Functional Check**

The functional check monitors the pressure for no increase when the purge cycle is started. To run this test the vehicle ignition is turned off, then a calibrated delay time (7 sec) is used. Once the delay expires, the pump and reverting valve are accuated. For a successful test result, the pressure must not increase by another threshold (50.0 kPa) within the given purge time – Typically purge is 5 seconds.

If the test is not successfully passed the purge cycle will be terminated immediately because of the risk of uncontrolled injection of reductant into the exhaust pipe.

| Reverting Valve Functional Check Operation: | |
|---|---|
| DTCs | P20A1 - Reductant Purge Control Valve Performance |
| Monitor execution | continuous |
| Monitor Sequence | P20A1 is inhibited by active P20A0 , P20A3 or P20A2 |
| Sensors/Actuators OK | reductant pump pressure sensor, reductant injector, reductant pump motor |
| Monitoring Duration | 7 secs after key off with no monitoring. Then 5 seconds of monitoring with pump on reverting valve actuated (purge) |

| Typical Reverting Valve Functional Check Malfunction Thresholds: |
|---|
| P20A1 Max. pressure increase >50.0 kPa error during purge (reverse flow expected) - 1 event > 50.0 kPa during the monitoring window. |

## Urea Heaters

Aqueous urea water solution (Diesel Exhaust Fluid) freezes at -11°C (12 deg. F). In order to keep the fluid liquid at low ambient temperatures, the system includes 3 heaters:

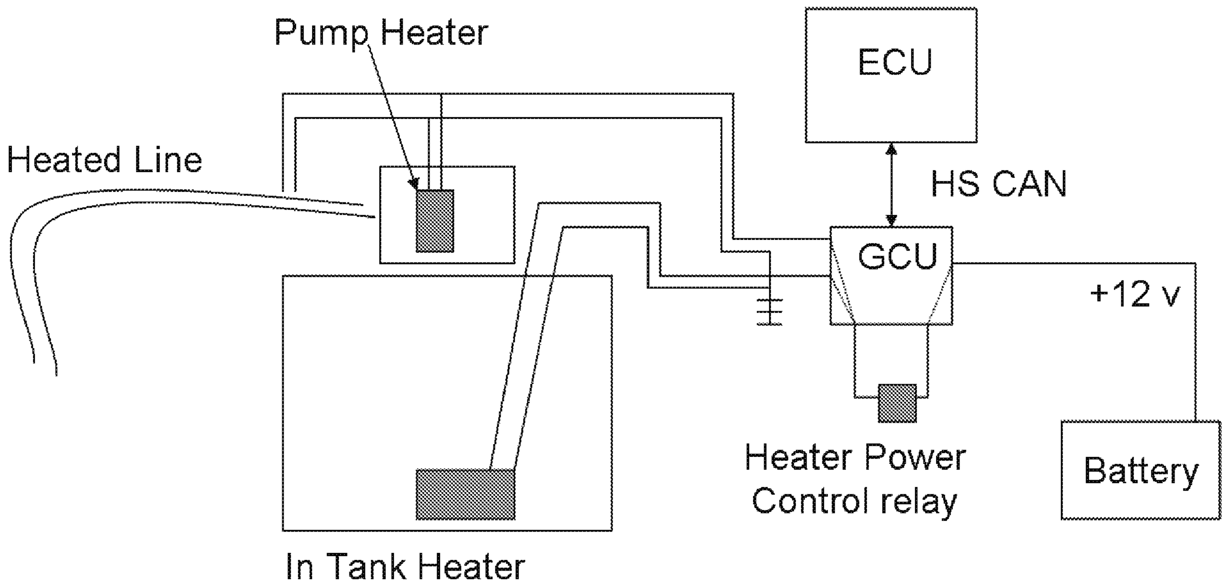
- tank heater (PTC heater element – self regulating)
- pump heater (PTC heater element – self regulating)
- pressure line heater (Resistance heater)

The heater power stages are located in the glow plug control module (GPCM). The tank heater is connected to heater power stage #1. The pressure line & pump heater are connected in parallel to heater power stage #2.

All SCR-heater related circuit checks are performed inside the GCU. The information is sent via CAN to the engine control module (ECM).

Additionally the GCU sends the supply voltage and the actual heater current for each circuit to the ECM.

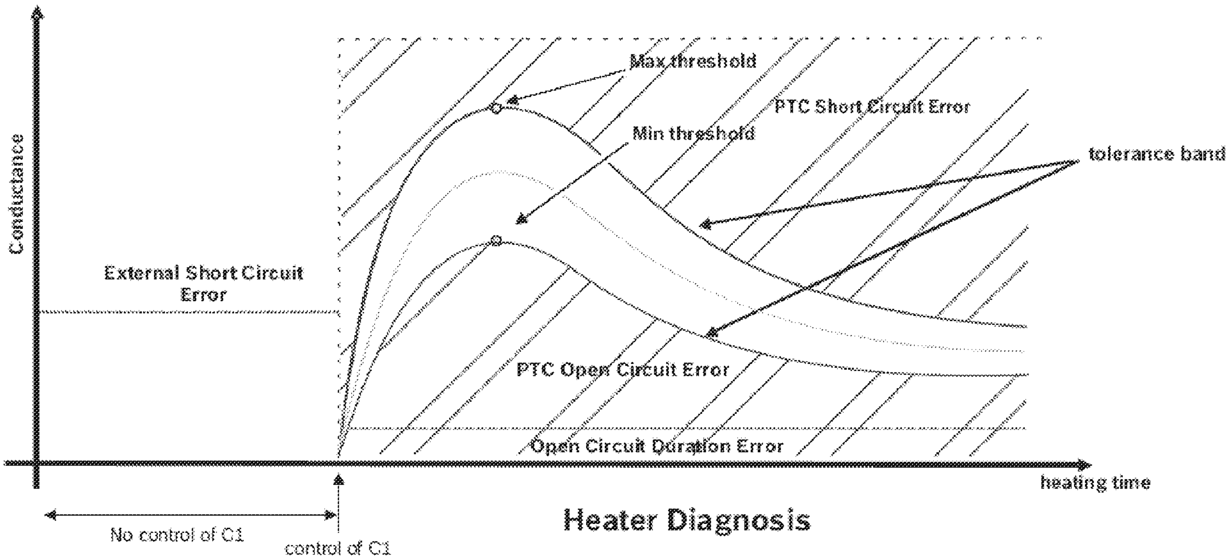
Based on this information the heater plausibility checks are performed on the ECM.



## Reductant Heater Plausibility Checks

Based on the information of heater voltage and heater current, the actual conductance at peak power is calculated for each heater circuit. This value is checked against the nominal value including tolerances.

Typical characteristic of PTC heater conductance:




| Reductant Heater Plausibility Check Operation: | |
|---|---|
| DTCs | P20BA – Reductant Heater "A" Control Performance<br>P20BE – Reductant Heater "B" Control Performance<br>P263D – Reductant Heater Driver Performance |
| Monitor execution | Once per drive cycle (at peak heater power) |
| Monitor Sequence | P20B9, P20BB, P20BC must complete for P20BA<br>P20BD, P20BF, P20C0 must complete for P20BE |
| Sensors/Actuators OK | none |
| Monitoring Duration | 1 event for fault detection |

| Typical Reductant Heater Plausibility Check Malfunction Thresholds: |
|---|
| P20BA: > nominal conductance of heater circuit #1 + max. tolerance or<br>< nominal conductance of heater circuit #1 – max. tolerance<br>P20BE: > nominal conductance of heater circuit #2 + max. tolerance or<br>< nominal conductance of heater circuit #2 – max. tolerance<br><br>P263D: Driver circuit temperatures > 125C |

**Additional plausibility check for heater circuit #2:**

Pump heater & pressure line heater are connected in parallel to heater power stage #2. In order to be able to detect a failure of just one of both heaters, the conductance of heater circuit #2 is continuously checked against a minimum threshold. E.g. if the pressure line heater gets disconnected after peak conductance occurred, neither the plausibility check nor the circuit checks inside the GCU can detect this error. Therefore this continuous check becomes necessary.

| Reductant Heater Plausibility Check Operation (Heater Circuit #2): | |
|---|---|
| DTCs | P20BE – Reductant Heater "B" Control Performance |
| Monitor execution | Continuously, if heater "B" is activated |
| Monitor Sequence | P20BD, P20BF, P20C0 must complete for P20BE |
| Sensors/Actuators OK | Pressure line heater |
| Monitoring Duration | 2200 ms for fault detection |

| Typical Reductant Heater Plausibility Check Malfunction Thresholds (Heater Circuit #2): |
|---|
| P20BE: conductance of heater circuit #2 < 0.3 $\Omega^{-1}$ |

**Reductant tank heater performance check (heater circuit #1):**

The tank heater is located in close proximity to the tank temperature sensor. Therefore the tank temperature sensor can be used to monitor the tank heater performance.

When the tank heater is activated, the tank temperature is expected to rise. If this is not the case a fault will be set. If the vehicle is operated for several consecutive short drive cycles, the test may require more than one drive cycle to complete.

| Reductant Heater Performance Check Operation (Heater Circuit #1): | |
|---|---|
| DTCs | P209F – Reductant Tank Heater Control Performance |
| Monitor execution | Once per heat cycle (after cold start) |
| Monitor Sequence | P20B9, P20BB, P20BC must complete for P209F |
| Sensors/Actuators OK | tank temperature sensor, tank heater |
| Monitoring Duration | 2200 ms for fault detection |

| Typical Reductant Heater Performance Check Malfunction Thresholds (Heater Circuit #1): |
|---|
| P209F: temperature increase < 0.5°C |

| Engine Control Unit (ECU) Monitor Operation: | |
|---|---|
| DTCs | P0600 - Serial Communication Link<br>P0601 - Internal Control Module Memory Checksum Error<br>P0606 - Control Module Processor<br>P060A - Internal Control Module Monitoring Processor Performance<br>P060B - Internal Control Module A/D Processing Performance<br>P060D - Internal Control Module Accelerator Pedal Position Performance<br>P0611 – Fuel Injector Control Module Performance<br>P061A - Internal Control Module Torque Performance<br>P061B - Internal Control Module Torque Calculation Performance<br>P061C - Internal Control Module Engine RPM Performance<br>P062B - Internal Control Module Fuel Injector Control Performance<br>P062F - Internal Control Module EEPROM Error<br>P06A6 - Sensor Reference Voltage "A" Circuit Range/Performance<br>P06A7 - Sensor Reference Voltage "B" Circuit Range/Performance<br>P06A8 - Sensor Reference Voltage "C" Circuit Range/Performance<br>P167F - Non-OEM Calibration Detected<br>P2507 - ECM / PCM Power Input Signal Low<br>P2508 - ECM / PCM Power Input Signal High<br>P2610 – ECM / PCM Engine Off Timer Performance |

| | |
|---|---|
| Monitor Execution | P0600, P0606, P060A, P060B, P060D, P0611, P061A, P061B, P061C,<br>P062B, P062F, P06A6, P06A7, P06A8, P167F, P2507, P2508,<br>P2610, – Continuous<br>P0601 – Postdrive |
| Monitor Sequence | None |
| Sensors OK | None |
| Typical Monitoring Duration | P0600, P0601, P0606, P060A, P060B, P060D, P061B, P061C, ,<br>P062B, P062F, P06A6, P06A7, P06A8, P167F, P2507, P2508, P0611 – 5 sec<br>P061A – 0.1 sec , P2610 – 8 sec |

| Typical Engine Control Unit (ECU) Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| P0600, P0606, P060A, P060B, P060D, P061A, P061B, P061C, P062B, P062F, P06A6, P06A7, P06A8, P167F, P2507, P2508, P2610: ECU energized (key-on, engine running, or post-drive before ECU shutdown) | | |
| P0601: Post-drive | | |
| P0611: Engine running or cranking | | |

**Typical Engine Control Unit (ECU) Monitor Malfunction Thresholds:**

P0600 – – A data transfer between chips in the ECU either is not possible or has invalid check bytes

OR Communication is interrupted between the CPU and the monitoring module

P0601 – An error is detected in the post-drive ROM test

P0606 – A communications error exists between the powerstage controller chip and the CPU OR an internal chip error has been detected within the voltage generation/monitoring system for the ECU OR voltage at 5V supply in ECU is <4.7V or > 5.3V

P060A – An irreversible error occurs with an operating system function call OR An irreversible error occurs in the test of the monitoring module

P060B – Failure on power-up calibration done for the A/D conversion module and A/D conversion time performed on ECU start OR >249 mV reading in the cycle following grounding of a specific voltage OR Cyclical conversion of a predetermined voltage results in <4727 mV or >4830 mV reading.

P060D – If either pedal voltage 1 or pedal voltage 2 < 742 mV and (pedal voltage 1) – 2 * (pedal voltage 2) > 547 mV OR If pedal voltage 1 and pedal voltage 2 >= 742 mV and (pedal voltage 1) – 2 * (pedal voltage 2) > 1055 mV

P0611 – If the raw voltage detected by an internal ECU voltage measurement for fuel system Nominal Voltage Calibration falls below 0 mV or above 3300 mV for the monitoring duration

P061A – Commanded inner torque > permissible inner torque at current engine operating condition

P061B – The energizing time for Zero Fuel Calibration is <10 ms or > 850 ms (beyond limits for P02CC-P02DA) OR The difference between programmed energizing time and actual energizing time exceeds 127.2 us or The requested time for start of energizing of a given fuel injection is outside the crank angle regime permitted for that injection

OR The correction in requested fuel injection quantity due to transient pressure effects within the fuel injector as calculated by the control software and as calculated by the monitor exceeds 5 mg for an injection

P061C – The engine speed calculated by the control software and the engine speed calculated by the monitor deviate by more than 400 RPM

P062B – If an error is detected in a requested post injection OR If requested energizing time exceeds 200 us when the controller is operating in overrun/decel fuel shut-off mode

P062F – An error is detected in an EEPROM read, write, or erase operation

P06A6 – Voltage output of sensor supply 1 is <4.7 V or >5.3 V

P06A7 – Voltage output of sensor supply 2 is <4.7 V or >5.3 V

P06A8 – Voltage output of sensor supply 3 <4.7 V or >5.3 V

P167F – a non-OEM calibration has been detected

P2507 – The 5V internal ECU supply is <4.2 V

P2508 – The 5V internal ECU supply is > 5.5 V

P2610 – If, during a key off event, engine coolant temperature decreases by 30 degrees and the engine off timer has not incremented at least 1200 seconds OR If, while running for 1200 seconds as measured by ECU timer, the timer used for engine off time and the time as determined by the secondary timer differ by at least 100 seconds OR In afterrun, if a requested 8 second stop timer measurement is <7.52 seconds or >8.48 seconds

| Idle Speed and Fuel Monitor Operation: | |
|---|---|
| DTCs | P0506 - Idle Control System - RPM Lower Than Expected<br>P0507 - Idle Control System - RPM Higher Than Expected<br>P054E - Idle Control System - Fuel Quantity Lower Than Expected<br>P054F - Idle Control System - Fuel Quantity Higher Than Expected |
| Monitor Execution | P0506, P0507, P054E, P054F - Continuous |
| Monitor Sequence | None |
| Sensors OK | P0506 - Engine Coolant Temperature (P0116, P0117, P0118, P0128, Crankshaft Sensor (P0335, P0336),<br>P0507 - Engine Coolant Temperature (P0116, P0117, P0118, P0128, Crankshaft Sensor (P0335, P0336),<br>P054E - Engine Coolant Temperature (P0116, P0117, P0118, P0128, Crankshaft Sensor (P0335, P0336),<br>P054F - Engine Coolant Temperature (P0116, P0117, P0118, P0128, , Crankshaft Sensor (P0335, P0336), |
| Typical Monitoring Duration | P0506 – 5 sec<br>P0507 – 5 sec<br>P054E – 5 sec<br>P054F – 5 sec |

| Typical Idle Speed and Fuel Monitor Entry Conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| P0506, P0507: | | |
| Engine idle speed governor active (define this more completely) | | |
| Engine Coolant Temperature (°C) | 0 | 120 |
| Vehicle Speed (kph) | | 1 |
| Engine RPM | 300 (stall speed) | 1500 (300 rpm above max requestable idle speed) |
| P054E, P054F: | | |
| Engine running | | |

| Typical Idle Speed and Fuel Monitor Malfunction Thresholds: |
|---|
| P0506 – If observed idle speed is 100 or more RPM below requested idle speed<br>P0507 – If observed idle speed is 160 or more RPM above requested idle speed<br>P054E – If calculated torque required for idle is 30+% below the minimum threshold of (insert threshold)<br>P054F – If calculated torque required for idle is 30+% above the maximum of threshold of (insert threshold) |

## Lack of Communication Codes:

**CAN Communications Error**

The TCM receives information from the ECM via the high speed CAN network. If the CAN link or network fails, the TCM no longer has torque or engine speed information available. The TCM will store a U0073 fault code and will illuminate the MIL immediately (missing engine speed) if the CAN Bus is off. The TCM will store a U0100 fault code and will illuminate the MIL immediately (missing engine speed) if it stops receiving CAN messages from the ECM.

| ECU CAN Communication Malfunctions | |
|---|---|
| DTCs | U0073 - Control Module Communication Bus "A" Off<br>U0074 - Control Module Communication Bus "B" Off<br>U0101 - Lost Communication with TCM<br>U0102 - Lost Communication with Transfer Case Control Module<br>U0121 - Lost Communication With Anti-Lock Brake System (ABS) Control Module<br>U0151 - Lost Communication With Restraints Control Module<br>U0212 - Lost Communication With Steering Column Control Module<br>U029D - Lost Communication With NOx Sensor "A"<br>U029E - Lost Communication With NOx Sensor "B"<br>U0307 - Software Incompatibility with Glow Plug Control Module<br>U0407 - Invalid Data Received from Glow Control Module<br>U059E - Invalid Data Received from NOx Sensor "A"<br>U059F - Invalid Data Received from NOx Sensor "B" |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | continuous |

| Typical Malfunction Thresholds |
|---|
| U0073 CAN Chip Driver detect CAN line short or open > 10 ms |
| U0074 CAN Chip Driver detect CAN line short or open > 10 ms |
| U0101 TCM master message not received for 1 sec |
| U0102 TCCM master message not received for 5 sec |
| U0121 ABS master message not received for 5 sec |
| U0151 RCM master message not received for 10 sec |
| U0212 SCCM master message not received for 5 sec |
| U029D Nox sensor master message not received for .75 sec |
| U029E Nox sensor master message not received for .75 sec |
| U0307 – Glow module reporting "safe glow" mode |
| U0407 - Calibration Verification Number not received by ECU |
| U059E - Calibration Verification Number not received by ECU |

Vehicle speed is received by the ECU over CAN from the ABS system or (if the ABS system is faulted on all 4 wheel speed sensors) the TCU through Output Shaft Speed calculation to wheel speed

| VS Communication Plausibility Malfunctions | |
|---|---|
| DTCs | P0500 Vehicle Speed Sensor "A" |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | continuous |

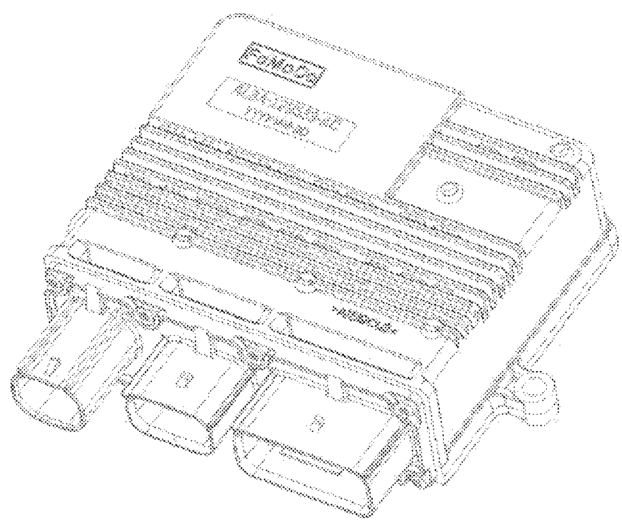
| Typical Malfunction Thresholds |
|---|
| VS signal is missing from the CAN system for 0.5 Seconds. |

## Glow Plugs

The diesel engine uses glow plugs to assist with cold weather starting and combustion until the cylinder is warm enough to operate normally. The glow plugs are duty cycle controlled and will overheat if constant 12V is applied.

The glow plugs are operated by the Glow Plug Control Module (GPCM). It contains 8 high current smart MOSFET drivers, one for each glow plug. Glow time and intensity are calculated on the basis of CAN signals (rpm, torque, engine coolant temp, air temp and BP.) The module also contains 3 drivers for the DEF (NOx reductant) heating and thawing system.

**GPCM**



The GPCM is connected to the ECU via Diesel high speed CAN. All data and diagnostics pass over this non-public communication bus. The standard operating voltages for the GPCM are 6.5 volts to 16 volts. Limited operation between 5.5v and 6.5v on the lower range and no operation below 5.5v. Glow function is disabled below 6.5v and above 16.5v.

| Glow Plug Module Operational Checks: | |
|---|---|
| DTCs | U0106 – Lost Communication with GPCM<br>P0381 – Glow Plug/Heater Indicator Circuit<br>P064C – Glow Plug Control Module<br>P06DF – Glow Plug Module Memory Checksum Error<br>P138B – Glow Plug Module System Voltage<br>P20C2 – Reductant Heater "C" Control Performance<br>P26C3 - Glow Plug Driver Performance<br>P06E5 - Glow Plug Control Module 1 Performance<br>P263E - Glow Plug Control Module 1 Over Temperature |
| Monitor execution | P06DF, P0381 at power up, otherwise continuous |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | ~1 second to register a malfunction |

| Glow Plug Module: Malfunction Thresholds: |
|---|
| Communication lost for > 5 seconds<br>Cluster detects wait to start lamp in wrong state (off when commanded on)<br>Any internal driver circuits detect fault (not switching or over temp) > 1 sec (glow plugs, urea heaters or relay)<br>RAM checksums do not match expected<br>GPCM main power feed voltage too low / too high / open circuit (< 6.5 volts or > 16 volts)<br>Low voltage detected on the Reductant Heater Circuit "C" < 5 volts |

| Glow Plug Circuit Open Load Check Operation: | |
|---|---|
| DTCs | P0671 – Cylinder 1 Glow Plug Circuit / Open<br>P0672 – Cylinder 2 Glow Plug Circuit / Open<br>P0673 – Cylinder 3 Glow Plug Circuit / Open<br>P0674 – Cylinder 4 Glow Plug Circuit / Open<br>P0675 – Cylinder 5 Glow Plug Circuit / Open<br>P0676 – Cylinder 6 Glow Plug Circuit / Open<br>P0677 – Cylinder 7 Glow Plug Circuit / Open<br>P0678 – Cylinder 8 Glow Plug Circuit / Open<br>P20B9 – Reductant Heater "A" Control Circuit / Open<br>P20BD – Reductant Heater "B" Control Circuit / Open<br>P20C1 – Reductant Heater "C" Control Circuit / Open |
| Monitor execution | Glow plugs in heating mode. Heaters operational |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | ~1 second to register a malfunction |

| Glow Plug Circuit Open Load: Malfunction Thresholds: |
|---|
| Individual glow plug circuit current < 1 A, Individual reductant heater circuit current < .2 A |

| Glow Plug Circuit Short to Battery Check Operation: | |
|---|---|
| DTCs | P066B – Cylinder 1 Glow Plug Circuit High<br>P066D – Cylinder 2 Glow Plug Circuit High<br>P066F – Cylinder 3 Glow Plug Circuit High<br>P067B – Cylinder 4 Glow Plug Circuit High<br>P067D – Cylinder 5 Glow Plug Circuit High<br>P067F – Cylinder 6 Glow Plug Circuit High<br>P068D – Cylinder 7 Glow Plug Circuit High<br>P068F – Cylinder 8 Glow Plug Circuit High<br>P20BC – Reductant Heater "A" Control Circuit High<br>P20C0 – Reductant Heater "B" Control Circuit High<br>P20C4 – Reductant Heater "C" Control Circuit High |
| Monitor execution | Glow plugs in heating mode. Heaters operational |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | ~1 second to register a malfunction for glow plugs<br>250 ms to register a malfunction for the reductant heaters |

| Glow Plug Circuit Short to Battery: Malfunction Thresholds: |
|---|
| Individual glow plug circuit = 0 Amps current, Individual reductant heater circuit = 0 Amps current |

| Glow Plug Circuit Short to Ground Check Operation: | |
|---|---|
| DTCs | P066A – Cylinder 1 Glow Plug Circuit Low<br>P066C – Cylinder 2 Glow Plug Circuit Low<br>P066E – Cylinder 3 Glow Plug Circuit Low<br>P067A – Cylinder 4 Glow Plug Circuit Low<br>P067C – Cylinder 5 Glow Plug Circuit Low<br>P067E – Cylinder 6 Glow Plug Circuit Low<br>P068C – Cylinder 7 Glow Plug Circuit Low<br>P068E – Cylinder 8 Glow Plug Circuit Low<br>P20BB – Reductant Heater "A" Control Circuit Low<br>P20BF – Reductant Heater "B" Control Circuit Low<br>P20C3 – Reductant Heater "C" Control Circuit Low |
| Monitor execution | Glow plugs in heating mode. Heaters operational. |
| Monitor Sequence | none |
| Sensors OK | none |
| Monitoring Duration | ~3 second to register a malfunction for glow plugs<br>250 ms to register a malfunction for the reductant heaters |

| Glow Plug Circuit Short to Battery: Malfunction Thresholds: |
|---|
| Individual glow plug circuit > 20 Amps current > 1 second<br>Individual glow plug circuit > 70 Amps current for > .2 ms<br>Reductant heater relay (circuit "A" & "B") > 15 Amps current > 250 ms<br>Reductant heater relay (circuit "C") > 6 Amps current > 250 ms |

| Glow Plug Circuit Resistance Out of Range Check: | |
|---|---|
| DTCs | P06B9 – Cylinder 1 Glow Plug Circuit Range / Performance<br>P06BA – Cylinder 2 Glow Plug Circuit Range / Performance<br>P06BB – Cylinder 3 Glow Plug Circuit Range / Performance<br>P06BC – Cylinder 4 Glow Plug Circuit Range / Performance<br>P06BD – Cylinder 5 Glow Plug Circuit Range / Performance<br>P06BE – Cylinder 6 Glow Plug Circuit Range / Performance<br>P06BF – Cylinder 7 Glow Plug Circuit Range / Performance<br>P06C0 – Cylinder 8 Glow Plug Circuit Range / Performance |
| Monitor execution | Glow plugs in heating mode. |
| Monitor Sequence | After Open circuit, short to battery and short to ground testing |
| Sensors OK | none |
| Monitoring Duration | ~3 second to register a malfunction |

| Glow Plug Circuit Short to Battery: Malfunction Thresholds: |
|---|
| Individual circuit > 2 ohms resistance |

## Turbocharger Actuator Signal Range Check

The diagnostics for the circuit range check on the pwm signal to the turbocharger VGT actuator are internal to the PWM power-stage. Open load, short-circuit to ground, and short-circuit to battery are detected on the single control line to the actuator.

| Turbocharger Control Circuit Open Load/Short to Ground/Short to Power: | |
|---|---|
| DTCs | P132A - Turbocharger/Supercharger Boost Control "A" Electrical |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 2 seconds to register a malfunction |

## Wastegate Vacuum Solenoid Signal Range Check

The 6.7L chassis cert engine is equipped with a vacuum actuated wastegate. Vacuum is supplied at all times to the wastegate vacuum regulating valve, which is controlled via PWM signal. When a PWM signal is applied to the vacuum regulating valve, the valve opens and vacuum is applied to the wastegate, and the wastegate opens. There is an intrusive monitor to verify wastegate movement, and in addition there are open load/short circuit to ground/battery diagnostics on the vacuum regulating valve.

The diagnostics for the circuit range check on the pwm signal to the wastegate vacuum control solenoid are internal to the PWM power-stage. Open load, short-circuit to ground, and short-circuit to battery are detected on the single control line to the solenoid.

| Wastegate Open Load Operation: | |
|---|---|
| DTCs | P0243 - Turbocharger/Supercharger Wastegate Solenoid "A" |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 2 seconds to register a malfunction |

| Wastegate Short Circuit Check Operation: | |
|---|---|
| DTCs | P0245 – Turbocharger/Supercharger Wastegate Solenoid "A" Low<br>P0246 – Turbocharger/Supercharger Wastegate Solenoid "A" High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 2 seconds to register a malfunction. |

## Miscellaneous ECU Errors:

### Vehicle Configuration Information Errors

Vehicle specific information is stored in two locations: the VID block within the ECU and within the body control module (BCM). The following fault codes are immediate malfunction lamp codes (1 drive cycle) and reflect that the vehicle configuration information has been improperly configured.

| VID Block Configuration | |
|---|---|
| DTCs | P0602 - Internal Control Module Keep Alive Memory (KAM) Error<br>P0610 - Control Module Vehicle Options Error<br>P0630 - VIN Not Programmed or Incompatible - ECM/PCM<br>P1639 - Vehicle ID Block Corrupted, Not Programmed<br>P264F - Engine Serial Number Not Programmed or Incompatible |

| ECU Main Relay | |
|---|---|
| DTCs | P0685 - ECM/PCM Power Relay Control Circuit/Open<br>P068A – ECM/PCM Power Relay De-Energized Too Early |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Monitoring Duration | 0.5 seconds to register a malfunction. |

# Comprehensive Component Monitor - Transmission

### General

The MIL is illuminated for all emissions related electrical component malfunctions. For malfunctions attributable to a mechanical component (such as a clutch, gear, band, valve, etc.), some transmissions are capable of not commanding the mechanically failed component and providing the remaining maximum functionality (functionality is reassessed on each power up)- in such case a non-MIL Diagnostic Trouble Code (DTC) will be stored and, if so equipped, the Wrench" Light will flash.

## Transmission Inputs

| Transmission Range Sensor Check Operation: | |
|---|---|
| DTCs | P0706 - Out of range signal frequency for PWM TRS<br>P0707, P0708 - Low /High duty cycle for PWM TRS |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 5 seconds of signal out of range |

| Typical TRS check entry conditions: | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| battery voltage | 7v | 18v |

| Typical TRS malfunction thresholds: |
|---|
| PWM TRS: Frequency > 175 Hz or < 75 Hz, Duty Cycle > 90% or < 10% |

| Output Shaft Speed Sensor Functional Check Operation: | |
|---|---|
| DTCs | P0720 – OSS circuit<br>P0722 – OSS no signal |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | TSS, Wheel Speed |
| Monitoring Duration | 30 seconds |

| Typical OSS functional check entry conditions: | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| Gear selector position | drive | |
| Engine rpm (above converter stall speed) OR | 3000 rpm | |
| Turbine shaft rpm (if available) OR | 1500 rpm | |
| Output shaft rpm | 300 - 650 rpm | |
| Vehicle speed (if available) | 12.5 - 15 mph | |

| Typical OSS functional check malfunction thresholds: |
|---|
| Circuit/no signal - vehicle is inferred to be moving with positive driving torque and OSS < 100 to 200 rpm for 5 to 30 seconds |

| Turbine Shaft Speed Sensor Functional Check Operation: | |
|---|---|
| DTCs | P0715 – TSS circuit<br>P0717 – TSS no signal |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | OSS, Wheel Speed |
| Monitoring Duration | 30 seconds |

| Typical TSS functional check entry conditions: | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| Gear selector position | Forward range | |
| Engine rpm (above converter stall speed) OR | 3000 rpm | |
| Output shaft rpm OR | 600 - 650 rpm | |
| Vehicle speed (if available) | 12.5 - 15 mph | |

| Typical TSS functional check malfunction thresholds: |
|---|
| Circuit/no signal - vehicle is inferred to be moving with positive driving torque and TSS < 200 rpm for 5 – 30 seconds |

| System voltage: | |
|---|---|
| DTCs | P0882 – voltage out of range low<br>P0883 – voltage out of range high |
| Monitoring execution | electrical - continuous |

| Transmission Fluid Temperature Sensor Functional Check Operation: | |
|---|---|
| DTCs (non-MIL) | P0712, P0713 or P0710 - Opens/shorts<br>P1711 – in range failures<br>P1783 – Transmission overtemperature (non-MIL fault, TFT > 275 deg F for 5 seconds) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | ECT substituted if TFT has malfunction |
| Monitoring Duration | 5 seconds for electrical, 600 seconds for functional check |

| Typical TFT Stuck Low/High check entry conditions: | | |
|---|---|---|
| Auto Transmission Entry Conditions | Minimum | Maximum |
| Engine Coolant Temp (hot or cold, not midrange) | > 100 $^{o}$F | < 20 $^{o}$F |
| Time in run mode | 500 – 600 sec | |
| Time in gear, vehicle moving, positive torque | 150 sec | |
| Vehicle Speed | 15 mph | |
| Time with engine off (cold start) OR | 420 min | |
| Engine Coolant Temp AND Trans Fluid Temp (inferred cold start) | | 122 $^{o}$F |

| Typical TFT malfunction thresholds: |
|---|
| Opens/shorts: TFT voltage <0.05 or > 4.6 volts for 5 – 12 seconds<br>TFT Stuck low/high, i.e. TFT stuck at high temperature or stuck at low temperature):<br>Stores a fault code if TFT stabilizes (stops increasing if temperature < 70 deg F, stops decreasing if temperature > 225 deg F) before reaching the temperature region where all MIL tests are enabled (70 to 225 deg F). If TFT remains constant (+/- 2 deg F) for approximately 2.5 minutes of vehicle driving outside the 70 to 225 deg F zone a P0711 fault code will be stored. Old logic used to indicate a "pass" for a single delta, and not test until the normal operating region (70-225 deg F) was reached. |
| |

| CAN: | |
|---|---|
| DTCs | U0073 – CAN bus off<br>U0100 – Lost communication with ECM |
| Monitoring execution | Continuous |
| Monitoring sequence | none |

## Transmission Outputs

| Transmission Solenoid Power Control (TSPC – provides power to all transmission solenoids: | |
|---|---|
| DTCs | P0657 – TSPC1 fault, impacts SSA, SSC, SSE<br>P2669 – TSPC2 fault, impacts SSB, SSD, TCC and LPC |
| Monitoring execution | electrical - continuous |
| Monitor sequence | Disables individual solenoid circuit fault detection if either above DTC sets and power is removed from all solenoids (one relay, removes power from both TSPC1 and TSPC2 wires) |

| Shift Solenoid Check Operation: | |
|---|---|
| DTCs | SS A - Electrical: P0750 (Open), P0973 (short to ground), P0974 (short to power)<br>Functional: P0751 (stuck off), P0752 (stuck on)<br>SS B - Electrical: P0755 (Open), P0976 (short to ground), P0977 (short to power)<br>Functional: P0756 (stuck off), P0757 (stuck on)<br>SS C - Electrical: P0760 (Open), P0979 (short to ground), P0980 (short to power)<br>Functional: P0761 (stuck off), P0762 (stuck on)<br>SS D - Electrical: P0765 (Open), P0982 (short to ground), P0983 (short to power)<br>Functional: P0766 (stuck off), P0767 (stuck on)<br>SS E - Electrical: P0770 (Open), P0985 (short to ground), P0986 (short to power)<br>Functional: P0771 (stuck off), P0772 (stuck on) |
| Monitor execution | electrical - continuous, functional - continuous |
| Monitor Sequence | None |
| Sensors OK | TRS, TSS and OSS ok for functional diagnostics |
| Monitoring Duration | 0.5 to 5 seconds for electrical checks, 3 clutch failed to apply (stuck off) or release (stuck on) events for functional check |

| Typical Shift Solenoid mechanical functional check entry conditions: | | |
|---|---|---|
| Entry Conditions (with turbine speed) | Minimum | Maximum |
| Gear ratio calculated | each gear | |
| Throttle position | positive drive torque | |

| Typical Shift Solenoid mechanical functional check entry conditions: | | |
|---|---|---|
| Entry Conditions (without turbine speed) | Minimum | Maximum |
| Rpm drop is obtained | each shift | |
| Throttle position | positive drive torque | |

| Typical Shift Solenoid malfunction thresholds: |
|---|
| Electrical circuit check: Output driver feedback indicates an open, short to ground or open circuit for 0.5 – 5.0 seconds |

| Gear Ratio Check Operation: | |
|---|---|
| DTCs | P0731 - incorrect gear 1 ratio<br>P0732 - incorrect gear 2 ratio<br>P0733 - incorrect gear 3 ratio<br>P0734 - incorrect gear 4 ratio<br>P0735 - incorrect gear 5 ratio<br>P0729 - incorrect gear 6 ratio<br>P0736 - incorrect reverse ratio 6 |
| Monitor execution | Continuous, in each gear |
| Monitor Sequence | None |
| Sensors OK | TSS, OSS, wheel speed |
| Monitoring Duration | 12 seconds |

| Typical Forward Gear Ratio check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Gear selector position | forward range,<br>> 8 seconds | |
| Engine Torque | 100 NM | |
| Throttle position | 10% | |
| Not shifting | > 0.5 seconds | |
| Engine/input Speed | 550 rpm | |
| Output Shaft Speed | 250 rpm | 1350 rpm |

| Typical Neutral Gear Ratio check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Gear selector position | forward range,<br>> 1 second | |
| Absolute value of Engine rpm – Turbine rpm | | 150 rpm |
| Output Shaft Speed | | 500 rpm |

| Typical Gear Ratio malfunction thresholds: |
|---|
| Forward gear check: > 20% error in commanded ratio for > 12 seconds |

| Typical Shift Completion check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Gear selector position | forward range | |
| Transmission Fluid Temp | 50 $^{o}$F | |
| Engine/input Speed | 1200 rpm | |
| Output Shaft Speed | 256 rpm | |

| Typical Shift Completion malfunction thresholds: | |
|---|---|
| Up-shift rpm check: | rpm does not drop by > 30 rpm |
| Down-shift rpm check: | rpm does not increase by > 30 rpm |
| Up-shift rpm check: | rpm increases (flares) by > 300 rpm |

| Torque Converter Clutch Check Operation: | |
|---|---|
| DTCs | Electrical: P0740 (open), P0742 (short to ground), P0744 (short to power)<br>Functional: P0741 (stuck off), P2758 (stuck on)<br>Note: P2758 is non-MIL, all other TCC DTC's are MIL |
| Monitor execution | electrical - continuous,<br>mechanical - TCC fails to apply 3 times (stuck off) or fails to release 3 times (stuck on) |
| Monitor Sequence | None |
| Sensors OK | TSS, OSS |
| Monitoring Duration | Electrical – 5 seconds, Functional - 3 lock-up or release events |

| Typical TCC mechanical functional check stuck off entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Throttle Position | steady | |
| Engine Torque | positive drive torque | |
| Transmission Fluid Temp | 70 $^{o}$F | 225 $^{o}$F |
| Commanded TCC pressure (0 rpm slip) | 55 psi | none |
| Not shifting | | |

| Typical TCC malfunction thresholds: |
|---|
| Electrical circuit check: Output driver feedback circuit does not match commanded driver state for 0.5 – 5.0 seconds |
| Mechanical check, stuck off: Slip across torque converter > 100 for 3 seconds after each of 3 lock events |
| Mechanical check, stuck on: Slip across torque converter < 20 rpm with converter commanded off in at least 3 different gears |

| Pressure Control Solenoid Check Operation: | |
|---|---|
| DTCs | P0960, P0962, P0963 - PC A opens/shorts<br>P0961 - PC A current range |
| Monitor execution | Continuous |
| Monitor Sequence | none |
| Sensors OK | |
| Monitoring Duration | Electrical: 5 seconds, |

| Typical Pressure Control Solenoid mechanical functional check entry conditions: | | |
|---|---|---|
| Entry Conditions | Minimum | Maximum |
| Gear ratio calculated | each gear | |
| Transmission Fluid Temperature | 70 °F | 225 °F |
| Throttle Position | positive drive torque | |

| Typical Pressure Control Solenoid malfunction thresholds: |
|---|
| Electrical circuit check: Output driver feedback circuit does not match commanded driver state for 0.5 – 5.0 seconds<br>Electrical current check: Feedback current out of range for 0.5 seconds |

## Transmission Control Module (TCM)

| TCM | |
|---|---|
| DTCs | P0604 – RAM fault present<br>P0605 – ROM fault present<br>P0607 – CPU reset fault<br>P06B8 – NVRAM error |
| Monitoring execution | Once per driving cycle at start-up except reset monitoring which is continuous |
| Monitor sequence | non |

| ADLER (chip that controls the transmission solenoids): | |
|---|---|
| DTCs | P1636 – lost communication (over internal SPI network) with ADLER chip |
| Monitoring execution | electrical - continuous |
| Monitor sequence | Transmission enters mechanical limp home (get P, R, N and 5M with open TCC and max line) if the main micro cannot communicate with the ADLER chip |

| Transmission ID (TRID) block (contains solenoid characterization data | |
|---|---|
| DTCs | P163E – programming error (checksum fault)<br>P163F – TRID data not programmed |
| Monitoring execution | Start-up – TRID is a portion of flash memory, either it is present at start-up or not |
| Monitor sequence | Transmission solenoid data missing, enters limited operating mode (P, R, N and 3rd gear with open TCC). |

# 6R140 (RWD) Transmission with external PCM or TCM

## Transmission Control System Architecture

Starting in 2011 MY 6R140 replaces 5R110W in Super Duty truck applications.

The 6R140 is a 6-speed, step ratio transmission that is controlled by an external PCM (gas engine applications) or TCM (Diesel engine applications). For Diesel the TCM communicates to the Engine Control Module (ECM), ABS Module, Instrument Cluster and Transfer Case Control Module using the high speed CAN communication link. The TCM incorporates a standalone OBD-II system. The TCM independently processes and stores fault codes, freeze frame, supports industry-standard PIDs as well as J1979 Mode 09 CALID and CVN. The TCM does not directly illuminate the MIL, but requests the ECM to do so. The TCM is located outside the transmission assembly. It is not serviceable with the exception of reprogramming.

## Transmission Inputs

### Transmission Range Sensor

6R140 uses a Non-contacting Pulse Width Modulated Transmission Range Sensor (TRS) that provides a duty cycle signal for each position. This signal is transmitted at a frequency of 125 Hz. The PCM / TCM decode the duty cycle to determine the driver-selected gear position (Park, Rev, Neutral, OD, 3, 2, 1). This input device is checked for frequency out of range (P0706), duty cycle out of range low (P0707) and duty cycle out of range high (P0708)

### Speed Sensors

The Turbine Shaft Speed (TSS) sensor and Output Shaft Speed (OSS) sensor are Hall effect sensors.

The Turbine Shaft Speed sensor is monitored by a rationality test, if engine speed and output shaft speed are high and a gear is engaged, it can be inferred that the vehicle is moving. If there is insufficient output from the TSS sensor a fault is stored (P0715).

The Output Shaft Speed sensor is monitored by a rationality test. If engine speed and turbine speed are high and a gear is engaged, it can be inferred that the vehicle is moving. If there is insufficient output from the OSS sensor a fault is stored (P0720).

### Transmission Fluid Temperature

The Transmission Fluid Temperature Sensor is checked for out of range low (P0712), out of range high (P0713), and in-range failures (P0711). P1783 sets if TFT exceeds 275 deg F for 5 seconds, indicating transmission overtemperature (non-MIL failure).

## Transmission Outputs

### Shift Solenoids (SS)

6R140 has 5 shift solenoids:

- SSA – a Variable Force Solenoid (VFS) that controls CB1234 (a brake clutch, grounds an element to the case, that is on in 1st, 2nd, 3rd and 4th gear)
- SSB – a VFS that controls C35R (a rotating clutch on in 3rd, 5th and Reverse)
- SSC – a VFS that controls CB26 (a brake clutch on in 2nd and 6th gear)
- SSD – a VFS that controls CBLR (a brake clutch on in 1st gear with engine braking and Reverse)
- SSE – a VFS that controls C456 (a rotating clutch on in 4th, 5th and 6th gear)

Output circuits are checked for opens, short to ground and short to power faults (codes listed in that order) by the "smart driver" (see ADLER below) that controls the solenoids (SSA P0750, P0973, P0974; SSB P0755, P0976, P0977; SSC P0760, P0979, P0980; SSD P0765, P0982, P0983; SSE P0770, P0985, P0986).

The shift solenoids are also functional tested for stuck on and stuck off failures. This is determined by vehicle inputs such as gear command, and achieved gear (based on turbine and output speed). In general the shift solenoid malfunction codes actually cover the entire clutch system (solenoid, valves, seals and the clutch itself since using ratio there is no way to isolate the solenoid from the rest of the clutch system)

For SSA thru SSE Diagnostics will isolate the fault into clutch functionally (non-electrical) failed off (SSA P0751, SSB P0756, SSC P0761, SSD P0766. SSE P0771) and clutch functionally failed on (SSA: P0752, SSB: P0757, SSC: P0762, SSD: P0767, SSE: P0772).

### Gear ratio errors:

If ratio errors are detected that do not match an expected pattern for a failed solenoid then gear ratio error fault codes (1st gear – P0731, 2nd gear – P0732, 3rd gear – P0733, 4th gear – P0734, 5th gear – P0735 or 6th gear – P0729) will be stored.

### Torque Converter Clutch

The Torque Converter Clutch (TCC) solenoid is a Variable Force Solenoid. TCC solenoid circuit is checked electrically for open, short to ground and short to power circuit faults internally by the "smart driver" that controls the solenoids (P0740, P0742, P0744).

The TCC solenoid is checked functionally for stuck off faults by evaluating torque converter slip under steady state conditions when the torque converter is fully applied. If the slip exceeds the malfunction thresholds when the TCC is commanded on, a TCC malfunction is indicated (P0741).

The TCC solenoid is monitored functionally for stuck on faults (P2758) by monitoring for lack of clutch slip when the TCC is commanded off, but this code is non-MIL because while a stuck on TCC solenoid may cause driveability complaints and/or cause engine stalls it does not impact emissions or fuel economy.

### Electronic Pressure Control (EPC)

The EPC solenoid is a variable force solenoid that controls line pressure in the transmission. The EPC solenoid is monitored for open, short to ground or short to power faults by the "smart driver" that controls the solenoid. If a short to ground (low pressure) is detected, a high side switch will be opened. This switch removes power from all 7 VFSs, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position. This solenoid is tested for open (P0960), short to ground (P0962), and short to power (P0963) malfunctions.

### Transmission Solenoid Power Controll (TSPC)

6F140 PCM or TCM has a internal high side switch called TSPC that can be used to remove power from all 7 solenoids simultaneously. If the high side switch is opened, all 7 solenoids will be electrically off, providing Park, Reverse, Neutral, and 5M (in all forward ranges) with maximum line pressure based on manual lever position.

Due to current limitations TSPC is split into 2 pins / wires at the PCM / TCM. TSPC A provides power to SSA, SSC and SSE. TSPC B provides power to SSB, SSD, TCC and LPC. Each wire can be tested independently; P0657 sets for an issue with TSPC-A, P2669 sets for an issue with TPSC-B.

Although there are 2 pins and wires between the PCM / TCM and the transmission bulkhead connector the PCM / TCM contains only one TSPC internally – so the FMEM for either wire being failed is to open TSCP inside the PCM / TCM, which removes power from all 7 solenoids, providing P, R, N and 5$^{th}$ gear with open TCC and max line as FMEM for any TPSC faults.

ADLER (chip that controls all 7 solenoids) diagnostics:

The solenoids are controlled by an ADLER chip. The main micro sends commanded solenoid states to the ADLER, and receives back solenoid circuit fault information.

If communication with the ADLER is lost a P1636 fault code will be stored. If this failure is detected the states of the solenoids are unknown, so the control system will open the high side switch (removes power from all the solenoids), providing P, R, N and 5M with open TCC and max line pressure.

### TRID Block

The TRID block is a portion of flash memory that contains solenoid characterization data tailored to the specific transmission to improve pressure accuracy.

The TRID block is monitored for two failures:

- TRID block checksum error / incorrect version of the TRID (P163E)
- TRID block not programmed (P163F)

If the TRID block is unavailable FMEM action limits operation to P, R, N and 3$^{rd}$ gear based on manual lever position until the issue is correct.

## Transmission Control Module (TCM – Diesel only)

The TCM has the same module diagnostics as a PCM:

P0604 - Powertrain Control Module Random Access Memory (RAM) Error indicates the Random Access Memory read/write test failed.

P0605 - Powertrain Control Module Read Only Memory (ROM) Error indicates a Read Only Memory check sum test failed.

P0607 - Powertrain Control Module Performance indicates incorrect CPU instruction set operation, or excessive CPU resets.

P06B8 - Internal Control Module Non-Volatile Random Access Memory (NVRAM) Error indicates Permanent DTC check sum test failed

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## CAN Communications Error

The TCM receives information from the ECM via the high speed CAN network. If the CAN link or network fails, the TCM no longer has torque or engine speed information available. The TCM will store a U0073 fault code and will illuminate the MIL immediately (missing engine speed) if the CAN Bus is off. The TCM will store a U0100 fault code and will illuminate the MIL immediately (missing engine speed) if it stops receiving CAN messages from the ECM. A U0401 fault codes will be stored if the ECM sends invalid/faulted information for the following CAN message items: engine torque, pedal position.

## TCM voltage

If the system voltage at the TCM is outside of the specified 9 to 16 volt range, a fault will be stored (P0882, P0883).

## On Board Diagnostic Executive

The On-Board Diagnostic (OBD) Executive is a portion of the PCM strategy that manages the diagnostic trouble codes and operating modes for all diagnostic tests. It is the "traffic cop" of the diagnostic system. The Diagnostic Executive performs the following functions:

- Stores freeze frame and "similar condition" data.
- Manages storage and erasure of Diagnostic Trouble Codes as well as MIL illumination.
- Controls and co-ordinates the execution of the On-Demand tests: Key On Engine Off (KOEO) and Key On Engine Running (KOER).
- Performs transitions between various states of the diagnostic and powertrain control system to minimize the effects on vehicle operation.
- Interfaces with the diagnostic test tools to provide diagnostic information (I/M readiness, various J1979 test modes) and responses to special diagnostic requests (J1979 Mode 08 and 09).
- Tracks and manages indication of the driving cycle which includes the time between two key on events that include an engine start and key off.

The diagnostic executive also controls several overall, global OBD entry conditions.

- The battery voltage must fall between 9.0 and 16.25 volts to initiate monitoring cycles.
- The engine must be started to initiate the engine started, engine running, and engine off monitoring cycles.
- The Diagnostic Executive suspends OBD monitoring when battery voltage falls below 11.0 volts.

The diagnostic executive controls the setting and clearing of pending and confirmed DTCs.

- A pending DTC and freeze frame data is stored after a fault is confirmed on the first monitoring cycle. If the fault recurs on the next driving cycle, a confirmed DTC is stored, freeze frame data is updated, and the MIL is illuminated. If confirmed fault free on the next driving cycle, the pending DTC and freeze frame data is erased on the next power-up.
- Pending DTCs will be displayed as long as the fault is present. Note that OBD-II regulations required a complete fault-free monitoring cycle to occur before erasing a pending DTC. In practice, this means that a pending DTC is erased on the next power-up after a fault-free monitoring cycle.
- After a confirmed DTC is stored and the MIL has been illuminated, three consecutive confirmed fault-free monitoring cycles must occur before the MIL can be extinguished on the next (fourth) power-up. After 40 engine warm-ups, the DTC and freeze frame data is erased.

The diagnostic executive controls the setting and clearing of permanent DTCs.

- A permanent DTC is stored when a confirmed DTC is stored, the MIL has been illuminated, and there are not yet six permanent DTCs stored.
- After a permanent DTC is stored, three consecutive confirmed fault-free monitoring cycles must occur before the permanent DTC can be erased.
- After a permanent DTC is stored, one confirmed fault-free monitoring cycle must occur, following a DTC reset request, before the permanent DTC can be erased. For 2010MY and beyond ISO 14229 programs a driving cycle including the following criteria must also occur, following the DTC reset request, before a permanent DTC can be erased:
    - Cumulative time since engine start is greater than or equal to 600 seconds;
    - Cumulative vehicle operation at or above 25 miles per hour occurs for greater than or equal to 300 seconds (medium-duty vehicles with diesel engines certified on an engine dynamometer may use cumulative operation at or above 15% calculated load in lieu of at or above 25 miles per hour for purposes of this criteria); and
    - Continuous vehicle operation at idle (i.e., accelerator pedal released by driver and vehicle speed less than or equal to one mile per hour) for greater than or equal to 30 seconds.
- A permanent DTC can not be erased by a KAM clear (battery disconnect). Additionally, its confirmed DTC counterpart will be restored after completion of the KAM reset (battery reconnect).

## Exponentially Weighted Moving Average

Exponentially Weighted Moving Averaging is a well-documented statistical data processing technique that is used to reduce the variability on an incoming stream of data. Use of EWMA does not affect the mean of the data; however, it does affect the distribution of the data. Use of EWMA serves to "filter out" data points that exhibit excessive and unusual variability and could otherwise erroneously light the MIL.

The simplified mathematical equation for EWMA implemented in software is as follows:

New Average = [New data point * "filter constant"] + [( 1 - "filter constant" ) * Old Average]

This equation produces an exponential response to a step-change in the input data. The "Filter Constant" determines the time constant of the response. A large filter constant (i.e. 0.90) means that 90% of the new data point is averaged in with 10% of the old average. This produces a very fast response to a step change. Conversely, a small filter constant (i.e. 0.10) means that only 10% of the new data point is averaged in with 90% of the old average. This produces a slower response to a step change.

When EWMA is applied to a monitor, the new data point is the result from the latest monitor evaluation. A new average is calculated each time the monitor is evaluated and stored in Keep Alive Memory (KAM). This normally occurs each driving cycle. The MIL is illuminated and a DTC is stored based on the New Average store in KAM.

In order to facilitate repair verification and DDV demonstration, 2 different filter constants are used. A "fast filter constant" is used after KAM is cleared/DTCs are erased and a "normal filter constant" is used for normal customer driving. The "fast filter" is used for 2 driving cycles after KAM is cleared/DTCs are erased, and then the "normal filter" is used. The "fast filter" allows for easy repair verification and monitor demonstration in 2 driving cycles, while the normal filter is used to allow up to 6 driving cycles, on average, to properly identify a malfunction and illuminate the MIL.

In order to relate filter constants to driving cycles for MIL illumination, filter constants must be converted to time constants. The mathematical relationship is described below:

Time constant = [ ( 1 / filter constant ) - 1 ] * evaluation period

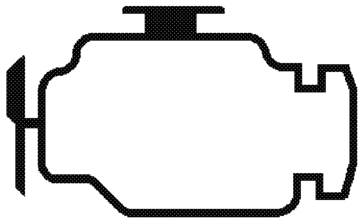
The evaluation period is a driving cycle. The time constant is the time it takes to achieve 68% of a step-change to an input. Two time constants achieve 95% of a step change input.

## Serial Data Link MIL Illumination

The OBD-II diagnostic communication messages utilize an industry standard 500 kbps CAN communication link.

The instrument cluster on some vehicles uses the same CAN data link to receive and display various types of information from the PCM. For example, the engine coolant temperature information displayed on the instrument cluster comes from the same ECT sensor used by the PCM for all its internal calculations.

These same vehicles use the CAN data link to illuminate the MIL rather than a circuit, hard-wired to the PCM. The PCM periodically sends the instrument cluster a message that tells it to turn on the MIL, turn off the MIL or blink the MIL. If the instrument cluster fails to receive a message within a 5-second timeout period, the instrument cluster itself illuminates the MIL. If communication is restored, the instrument cluster turns off the MIL after 5 seconds. Due to its limited capabilities, the instrument cluster does not generate or store Diagnostic Trouble Codes.



## Calculated Load Value

LOAD_PCT (PID $04) = $\dfrac{\text{Current Calculated Torque}}{\text{Maximum Engine Torque at conditions}}$

Where:
Current Calculation of torque is derived from the injected quantity of torque producing fuel and engine speed.
Maximum Engine Torque is derived from the maximum curve.

## I/M Readiness

The readiness function is implemented based on the SAE J1979/ISO 15031-5 format. Clearing codes using a scan tool results in the various I/M readiness bits being set to a "not-ready" condition. As each non-continuous monitor completes a full diagnostic check, the I/M readiness bit associated with that monitor is set to a "ready" condition. This may take one or two driving cycles based on whether malfunctions are detected or not. The readiness bit for comprehensive component monitoring is immediately considered complete since they are continuous monitors. The table below shows which monitors must complete for I/M readiness.

| I/M Readiness bit | Controlling Monitor |
|---|---|
| Boost Pressure | P0234 P0299 P026A P132B P1249 |
| CCM | Always Ready |
| EGR | P0401 P0402 P2457 P24A5 |
| Exhaust Gas Sensors | P0139 C3994 P229F P06EB P229E |
| Fuel System | P0088 P0093 P0088 C2414 P02CC P02D0 P02D8 P02CE P02D6 P02D4 P02D2 P02DA |
| HC Catalyst | P0420 |
| Misfire | P0301 P0303 P0307 P0302 P0306 P0305 P0304 P0308 P0300 |
| Nox Catalyst | P20EE P249C |
| PM Catalyst | P244A P249F P2002 |

## Power Take Off Mode

A Power Take-Off (PTO) unit refers to an engine driven output provision for the purposes of powering auxiliary equipment (e.g., a dump-truck bed, aerial bucket, or tow-truck winch). The OBD-II regulations have historically accommodated PTO by requiring the software to set all I/M readiness bits to "not complete" when PTO was engaged and reset them to their previous state when PTO was disengaged.

The 2013 MY OBD-II regulations have changed the requirement for PTO mode. This is in reaction industry request to accommodate PTO while the vehicle is stationary (stationary PTO) or while the vehicle is moving (mobile PTO). In mobile PTO, some OBD monitors may not run or may run at reduced frequency. The changes to the OBD-II regulations accommodate vehicles being I/M tested while PTO is engaged.

For the 2013 MY, the OBD II system is required to track the cumulative engine runtime with PTO active and set all the OBD II I/M readiness bits to "not complete" if 750 minutes of cumulative engine runtime with PTO active has occurred and all OBD monitors have not yet completed. The PTO timer pauses whenever PTO changes from active to not active and resumes counting when PTO is re-activated. The PTO timer is reset to zero after all the affected monitors have completed. If an OBD monitor is completely disabled by PTO mode, the affected IUMPR numerator and denominator must also be disabled.

This new requirement provides a 750 minute allowance to run all OBD monitors before all the I/M readiness bits are set to "not complete" in order to better accommodate vehicles that have monitors that run with reduced frequency in PTO mode or have monitors that don't run at all.

## In-Use Monitor Performance Ratio

Manufacturers are required to implement software algorithms that track in-use performance for each of the following components:

The table below shows which monitors must complete to increment each IUMPR numerator.

| IUMPR Counter Numerator | Controlling Monitor |
|---|---|
| NMHCCatalyst (500 Mile Denominator) | P0420 |
| NOxCatalyst | P20EE |
| PMFilter | P2459 P24A2 P24A0 P2457 P244A P2002 |
| EGSensor | P0139 P2201 P2A01 |
| EGR System Monitoring<br>(No VCT currently on Ford Diesel Products) | P2457 P24A5 |
| Boost Pressure | P0299 P1247 P0234 P1249 P132B |
| Fuel System | P02DA P02CC P02D0 P02D8 P02CE<br>P02D6 P02D4 P02D2 |

## Mode$06 Results

Mode$06 results are included for:

| Mode$06 Test Result | Controlling Monitor |
|---|---|
| HEGO 11 | P2201 P0139 P2A01 P229F |
| Cat Bank 1 | P0420 |
| Diesel EGR | P0401 P0402 P2457 P24A5 |
| Fuel System | P02CD P02D1 P02D9 P02CF P0170 P02D7 P02D5 P02D3P02DB |
| Boost Pressure Control | P026A P132B P0234 P0299 P1249 P00BC P00BD |
| NOx Catalyst | P20EE P207F |
| Misfire | P0308 P0301 P0303 P0307 P0302 P0306 P0305 P0304 |
| PM Catalyst | P2459 P2002 P24A2 |

# 2013 MY OBD System Operation

# Summary for Fiesta

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## Catalyst Efficiency Monitor

The Catalyst Efficiency Monitor uses an oxygen sensor after the catalyst to infer the hydrocarbon efficiency based on oxygen storage capacity of the ceria and precious metals in the wash coat. Under normal, closed-loop fuel conditions, high efficiency catalysts have significant oxygen storage. This makes the switching frequency of the rear HO2S very slow and reduces the amplitude of those. As catalyst efficiency deteriorates due to thermal and/or chemical deterioration, its ability to store oxygen declines and the post-catalyst HO2S signal begins to switch more rapidly with increasing amplitude. The predominant failure mode for high mileage catalysts is chemical deterioration (phosphorus deposition on the front brick of the catalyst), not thermal deterioration.

### Integrated Air/Fuel Method

The Integrated Air/Fuel Catalyst Monitor assesses the oxygen storage capacity of a catalyst after a fuel cut event. The monitor integrates how much excess fuel is needed to drive the monitored catalyst to a rich condition starting from an oxygen-saturated, lean condition. Therefore, the monitor is a measure of how much fuel is required to force catalyst breakthrough from lean to rich. To accomplish this, the monitor runs during fuel reactivation following a Decel Fuel Shut Off (DFSO) event. The monitor completes after a calibrated number of DFSO monitoring events have occurred. The IAF catalyst monitor can be used with either a wide range O2 sensor (UEGO) or a conventional switching sensor (HEGO).

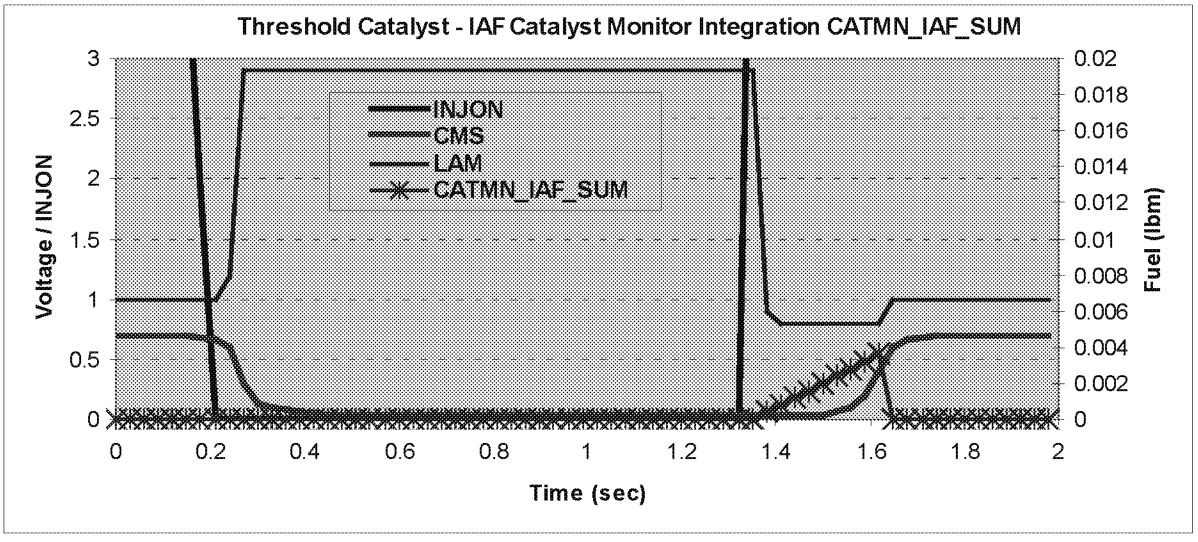
Functionally, the equation is:

$$IAF = \int \left( \frac{Fuel\_needed\_for\_stoich}{Fuel\_Measured} - Fuel\_needed\_for\_stoich \right)$$

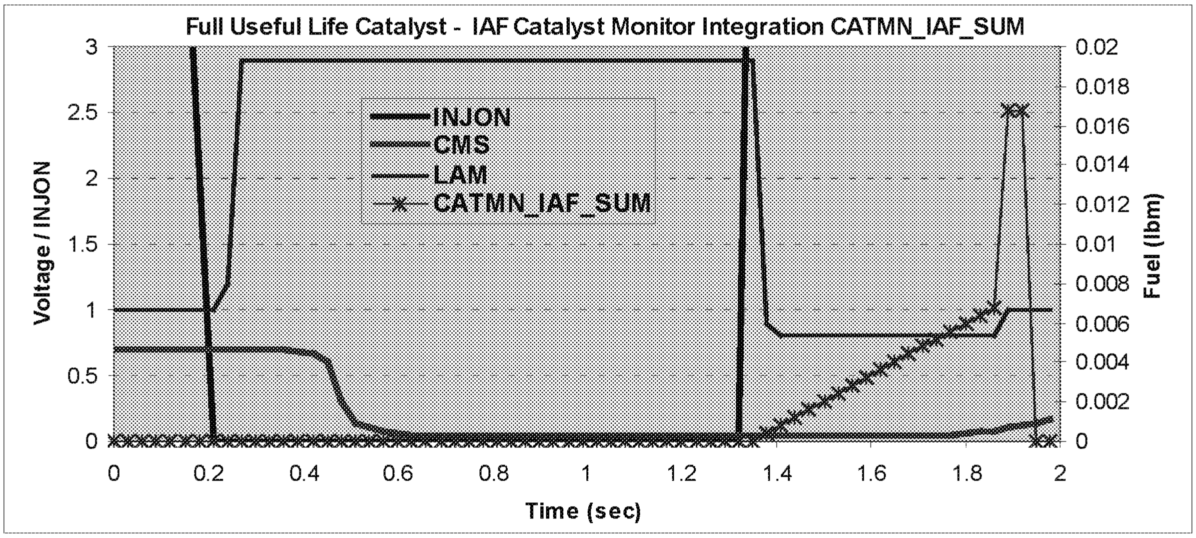
where the units are in pounds mass of fuel.

The monitor runs during reactivation fueling following an injector cut. The diagram below shows examples of one DFSO event with a threshold catalyst and with a Full Useful Life catalyst where:

- INJON = # of injectors on.
- CMS is the catalyst monitor sensor voltage. When the rear O2 sensor crosses 0.45 volts (i.e. rich) the monitor will complete for the given DFSO event.
- LAM (LAMBDA) is the front O2 sensor (UEGO) signal.
- CATMN_IAF_SUM is the integral from the equations above (Y axis on the right).



In the example above, CATMN_IAF_SUM is small because it doesn't take much fuel to break though a low oxygen storage threshold catalyst.




In the example above, CATMN_IAF_SUM is much larger because it takes a substantial amount of fuel to break though a high oxygen storage threshold catalyst.

There are two sets of entry conditions into the IAF catalyst monitor. The high level entry conditions determine that the monitor would like to run following the next injector fuel cut event. The lower level entry conditions determine that the fuel cut-off event was suitable for monitoring and the monitor will run as soon as the injectors come back on.

1. The high level entry conditions are met when:

- There are no sensor/hardware faults
- The base monitor entry conditions have been met (ECT, IAT, cat temp, fuel level, air mass)
- Required number of DFSO monitoring event have not yet completed

2. The lower level entry conditions are met when:

- The injectors are off
- The catalyst is believed to be saturated with oxygen (rear O2 indicates lean)
- The catalyst/rear O2 has been rich at least once since the last monitor event.

## General Catalyst Monitor Operation

Rear HO2S sensors can be located in various ways to monitor different kinds of exhaust systems. In-line engines and many V-engines are monitored by individual bank. A rear HO2S sensor is used along with the front, fuel-control HO2S sensor for each bank. Two sensors are used on an in-line engine; four sensors are used on a V-engine. Some V-engines have exhaust banks that combine into a single underbody catalyst. These systems are referred to as Y-pipe systems. They use only one rear HO2S sensor along with the two front, fuel-control HO2S sensors. Y-pipe system systems use three sensors in all. For Y-pipe systems which utilize switching front O2 sensors, the two front HO2S sensor signals are combined by the software to infer what the HO2S signal would have been in front of the monitored catalyst. The inferred front HO2S signal and the actual single, rear HO2S signal is then used to calculate the switch ratio.

Most vehicles monitor less than 100% of the catalyst volume – often the first catalyst brick of the catalyst system. Partial volume monitoring is done on LEV and LEV-II vehicles in order to meet the 1.75 * emission-standard threshold for NMHC and NOx. The rationale for this practice is that the catalysts nearest the engine deteriorate first, allowing the catalyst monitor to be more sensitive and illuminate the MIL properly at lower emission standards.

Many applications that utilize partial-volume monitoring place the rear HO2S sensor after the first light-off catalyst can or, after the second catalyst can in a three-can per bank system. (A few applications placed the HO2S in the middle of the catalyst can, between the first and second bricks.)

The Integrated A/F catalyst monitor was designed to allow monitoring 100% of the catalyst volume. It can be used for both partial and full volume monitoring.

Vehicles with the Integrated Air/Fuel catalyst monitor employ an improved version of the EWMA algorithm.

The EWMA logic incorporates several important CARB requirements. These are:

- Fast Initial Response (FIR): The first 4 tests after a code clear will process unfiltered data to quickly indicate a fault. The FIR will use a 2-trip MIL. This will help the service technician determine that a fault has been fixed.

- Step-change Logic (SCL): The logic will detect an abrupt change from a no-fault condition to a fault condition. The SCL will be active after the 4$^{th}$ catalyst monitor cycle and will also use a 2-trip MIL. This will illuminate the MIL when a fault is instantaneously induced.

- Normal EWMA (NORM): This is the normal mode of operation and uses an Exponentially Weighted Moving Average (EWMA) to filter the catalyst monitor test data. It is employed after the 4$^{th}$ catalyst test and will illuminate a MIL during the drive cycle where the EWMA value exceeds the fault threshold. (1 trip MIL).

| Catalyst Monitor Operation: | |
|---|---|
| DTCs | P0420 |
| Monitor execution | once per driving cycle |
| Monitor Sequence | HO2S response test complete and no DTCs prior to calculating switch ratio, no evap leak check or fuel monitor DTCs, |
| Sensors OK | ECT (P0118, P0117, P0119, P0116), IAT (P0111, P0112, P0113, P009A),: MAF,( P0102, P0103), front and rear O2 (P0132, P0131, P0134, P0130, P2A00, P2297, P0133, P0136, P0138, P0137, P0140, P2A01, P0139), front and rear O2 heaters (P0036, P0037, P0038, P0030, P0031, P0032) fuel monitor (P0171, P0172) |
| Monitoring Duration | 3 Decel Fuel Cutoff events for IAF catalyst monitor (approx 90 sec) |

| Typical IAF catalyst monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Coolant Temp | 72.75 °C | 110 °C |
| Intake Air Temp | -6.67 °C | 110 °C |
| Inferred catalyst mid-bed temperature | 649 °C | 816 °C |
| Fuel Level | 15% | |
| Air Mass | | 0.8 lb/min |
| No purge vapor flow for a minimum amount of time | 0.5 sec | |
| Rear O2 sensor rich since last monitor attempt | 0.45 volts | |
| Rear O2 sensor lean with injectors off (monitor will run when injectors turn back on) | | 0.1 volts |
| Short term fuel trim (STFT) OR absolute delta change in Average STFT | | 14.99 % |

| Typical malfunction thresholds: |
|---|
| Catalyst monitor index ratio > 0.75 (bank monitor) |

Mode $06 reporting for IAF Catalyst Monitor

The catalyst monitor results are converted to a ratio for Mode $06 reporting to keep the same look and feel for the service technician. The equation for calculating the Mode $06 monitor result is:

1 – (Actual reactivation fuel/ Good catalyst reactivation fuel)

Good catalyst reactivation fuel is intended to represent what the monitor would measure for a green catalyst.

| J1979 Catalyst Monitor Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| $21 | $91 | Catalyst Oxygen Storage Capacity and max. limit | Unit less |

** NOTE: In this document, a monitor or sensor is considered OK if there are no DTCs stored for that component or system at the time the monitor is running.

## Misfire Monitor

The method used for engine misfire detection is based on evaluating the engine speed fluctuations; it is commonly referred to as Engine Roughness. Engine torque is a function of engine speed, engine load, and the moment of inertia. In order to detect a misfiring cylinder, the torque of each cylinder is evaluated by using the crankshaft position signal to measure the time between sensor wheel teeth for each ignition event. This time is a measure of the mean value of the speed of this angular segment. A change in engine torque also results in a change in engine speed. In addition, different road surfaces, pot holes etc. will affect engine speed. Because mean engine speed is used to detect misfire, the effects caused by road surfaces have to be eliminated. The misfire monitor consists of following main parts:

### Data acquisition:

The duration of the crankshaft segment for each cylinder is measured continuously, every combustion cycle.

### Sensor wheel adaptation:

Crankshaft sensor wheel adaptation software is used to "learn" and correct for mechanical inaccuracies in the crankshaft position wheel tooth spacing. To prevent any fueling or combustion differences from affecting the correction factors, learning is done during decel-fuel cutout. When operating in decel-fuel cutout within a defined engine speed range, misfire monitoring is suspended and adaptation of the sensor wheel tolerances takes place. The adaptation values are stored in memory and used as correction factors for the calculation of the engine roughness.

### Calculation of the engine roughness:

The engine roughness is derived from the differences of the segment durations. Different statistical methods are used to distinguish between normal changes of the segment duration and the changes due to misfiring.

### Misfire Determination:

Misfire detection is performed by comparing the calculated engine roughness value for each cylinder to the engine roughness threshold (a table value). If the threshold is exceeded, a misfire is detected and the counter is incremented. This counter counts the number of misfires for all cylinders. In addition, a cylinder specific counter is also incremented.

The engine roughness threshold can be adjusted to account for the following factors to prevent false misfire indications:

> If engine coolant temperature is very cold, the engine roughness threshold is adjusted by a coolant temperature dependent factor.
>
> If cold start emission reduction actions are active for improved catalyst warm-up (elevated idle speed, spark retard, VVT timing, etc), the engine roughness threshold is adjusted by a catalyst warm-up dependent factor.
>
> Rough road conditions can induce crankshaft speed changes via the drive train and result in false misfire indications. When these conditions are detected, misfire detection is temporarily suspended for a calibratable time period. After this time, with no rough road conditions present, misfire monitoring will resume.

### Fault processing - Emission Threshold

The sum of the cylinder misfire counters is evaluated every 1000 rev period and compared to a single threshold value to indicate an emission-threshold malfunction, which can be either a single 1000 rev exceedence from startup or four subsequent 1000 rev exceedences on a drive cycle after start-up.

The cylinders with the highest misfire rate are flagged. If the misfire occurs again on a subsequent driving cycle, the MIL is illuminated and a cylinder specific fault is stored.

### Fault processing - Catalyst Damage Threshold

The weighted sum of the cylinder misfire counters is evaluated every 200 revolution period and compared to a table of threshold values to indicate a catalyst-damaging malfunction. The MIL is illuminated immediately. (The MIL blinks at a 1 Hz rate.)

The cylinders with the highest misfire rate are flagged. If one of the cylinder-specific counters is exceeding the catalyst damage threshold the following actions take place:

1. Closed loop fuel control is set to open loop.

2. Downstream O2 sensor fuel trim is suspended

3. A cylinder-specific fault code is stored.

4. The fuel injector to the misfiring cylinder is turned off (a maximum of one cylinder)

All misfire counters are reset after each interval.

### Similar Conditions

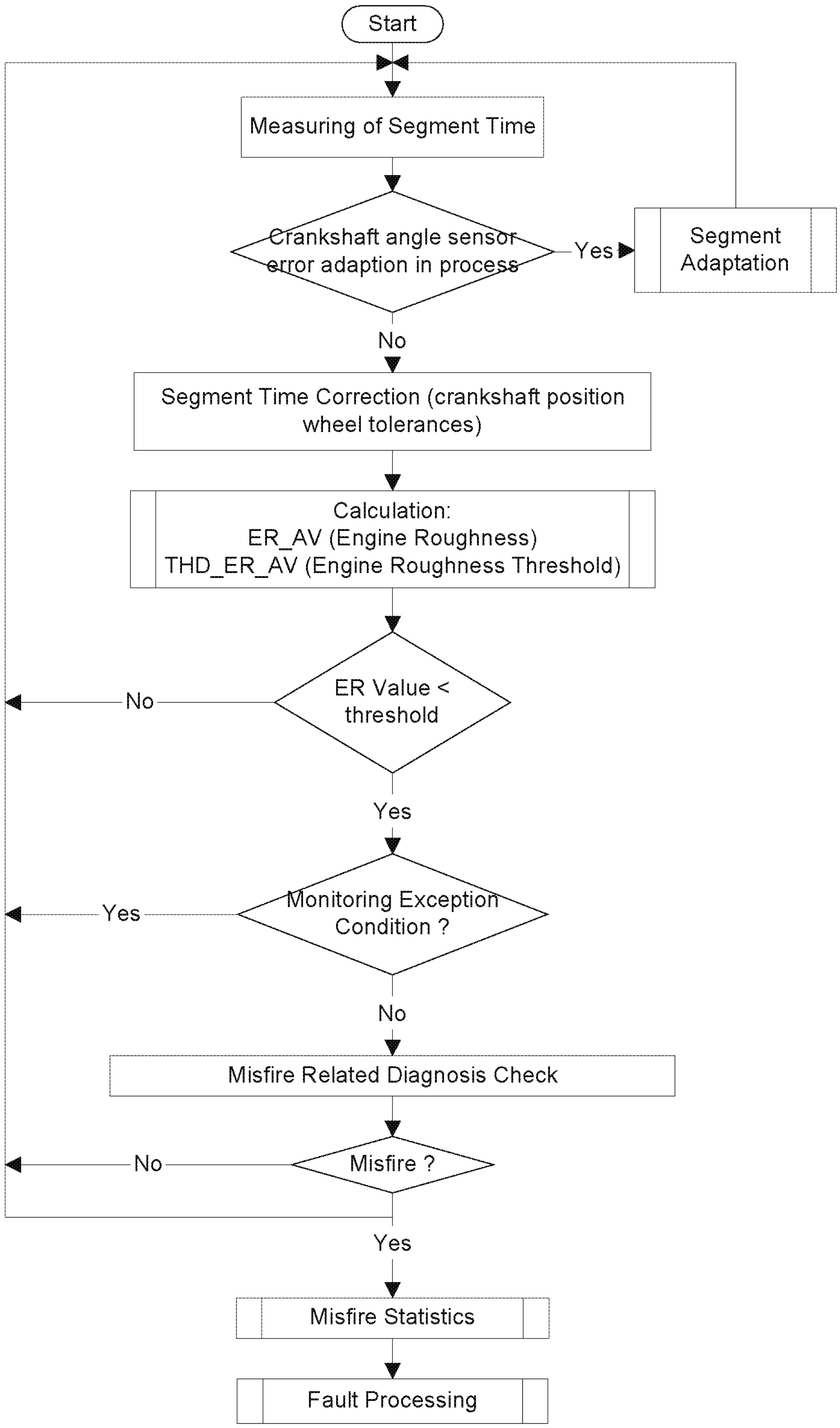
When the engine management system recognizes a failure in the misfire or fuel systems, the engine management system is required to record the conditions present when the fault occurred. These conditions recorded include engine speed, engine load (MAF), and warm up status of the first event that resulted in the storage of a code. These conditions stored are referred to as similar conditions.

Once the similar conditions are met without a failure in the misfire or fuel system, the flag is set to 1. Once this flag is set the driving cycle counter for that failure can be decrement.

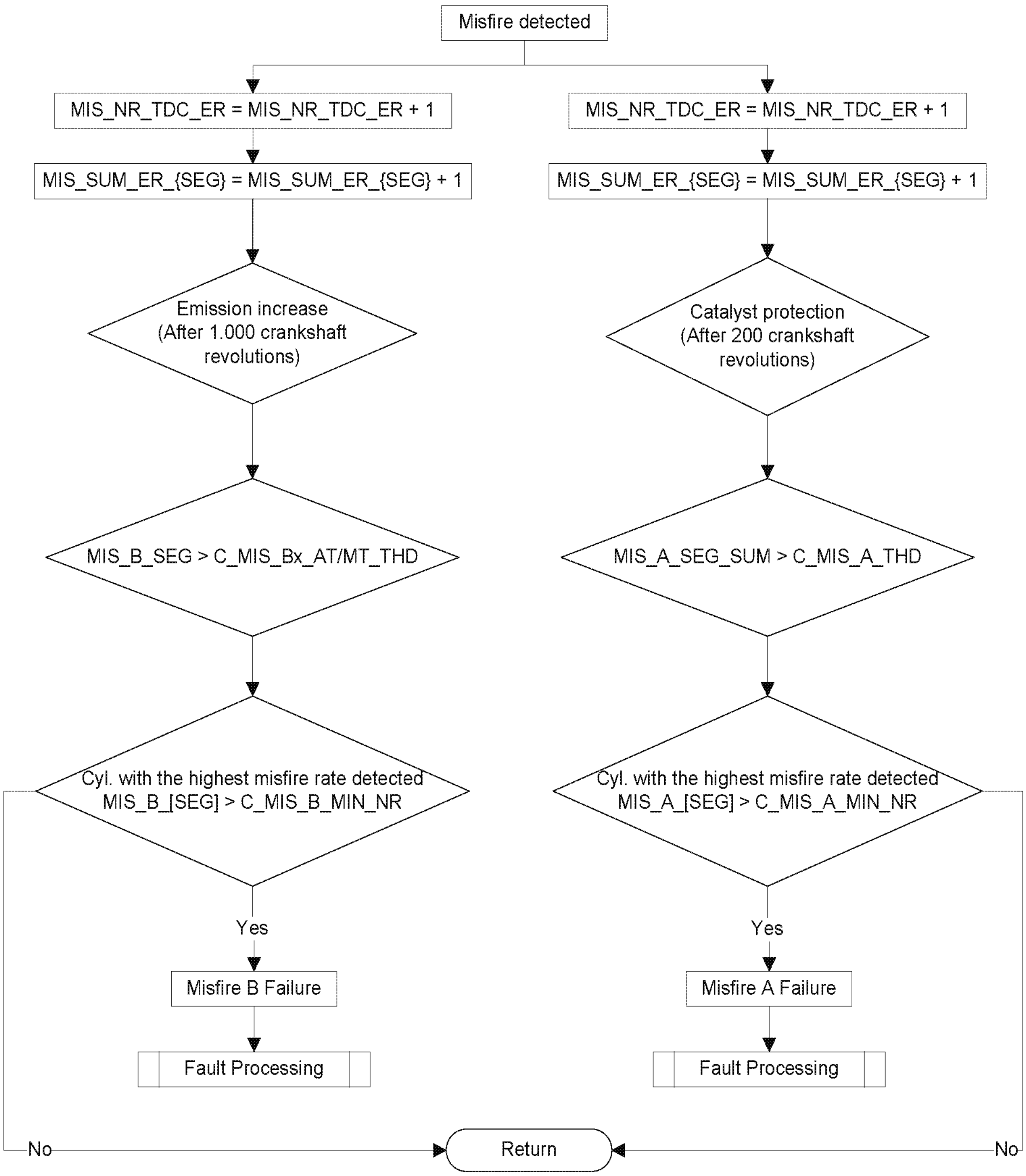
The code and stored freeze frame conditions may be erased if similar conditions are not encountered during the next 80 driving cycles immediately following the initial detection of the malfunction.

The MIL is extinguished after three consecutive cycles in which similar conditions have been encountered without exceeding the fuel system diagnostic thresholds.

## Misfire Threshold Processing



## Misfire Determination Processing



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| Misfire Monitor Operation: | |
|---|---|
| DTCs | P0300 (general misfire),<br>P0301 P0302, P0303, P0304 (specific cylinder misfire)<br>P315 (profile adaption values at limit) |
| Monitor execution | Continuous, misfire rate calculated every 200 or 1000 revs after start: (after 2 crankshaft revolutions) |
| Monitor Sequence | None |
| Sensors OK | CKP(P0335, P0336), BARO (P2227, P2228, P2229), TPS (P0122, P0123, P0222, P0223), ECT |
| Monitoring Duration | Entire driving cycle (see disablement conditions below) |

| Typical misfire monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Time since engine start-up | +2 crankshaft revolutions | |
| Engine load | > zero load line; all positive torque range | |
| RPM Range (2 revs after exceeding 150 rpm below “drive” idle rpm) | 550 rpm | 6000 rpm |
| Engine Coolant Temperature | -7 °C | |
| Injector Cut Off | Not active | |
| BARO | 75 kPa | |
| Fuel tank level | 5 % | |
| Maximum engine speed threshold target wheel adaptation | 5504 | |
| Minimum engine speed threshold for target wheel adaptation | 1696 | |

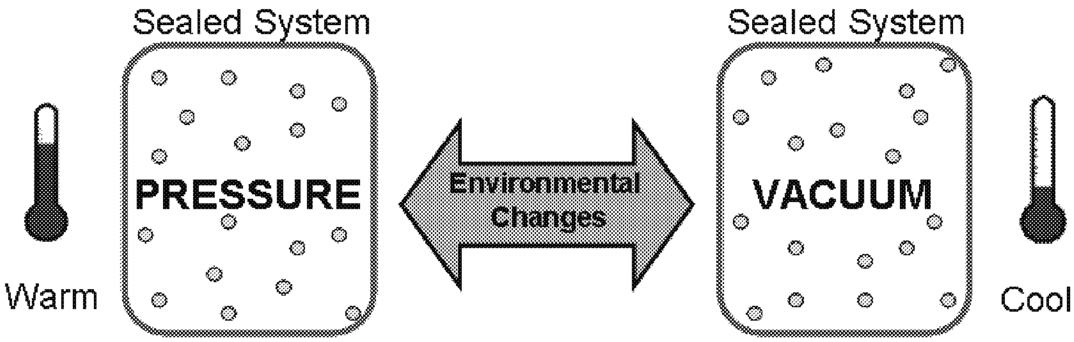
| Typical misfire temporary disablement conditions: |
|---|
| Fuel shut-off due to vehicle-speed limiting or engine-rpm limiting mode |
| Not during torque interventions by traction control |
| High rate of change of torque (heavy throttle tip-in or tip out), > 503.8.to .949.0 deg/sec |
| High rate of change of MAF ((heavy throttle tip-in or tip out), > 35 to 40 mg/stroke |

| Typical misfire monitor malfunction thresholds: |
|---|
| Type A (catalyst damaging misfire rate): ≥ 5 % |
| Type B (emission threshold rate): ≥1% |
| Segment Adaptation values at the limit (Adaptation Tolerance): 10.1% |
| Signal Implausible / Missing/ Adding 1 tooth or more (Incorrect number of teeth per rotation): |

| J1979 Misfire Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | |
| A1 | $0C | Total misfire counts for last/current driving cycle | events |
| A2 | $0B | Cylinder #1 EWMA misfire counts for previous driving cycles | events |
| A2 | $0C | Cylinder #1 Misfire counts for last/current driving cycle | events |
| A3 | $0B | Cylinder #2 EWMA misfire counts for previous driving cycles | events |
| A3 | $0C | Cylinder #2 Misfire counts for last/current driving cycle | events |
| A4 | $0B | Cylinder #3 EWMA misfire counts for previous driving cycles | events |
| A4 | $0C | Cylinder #3 Misfire counts for last/current driving cycle | events |
| A5 | $0B | Cylinder #4 EWMA misfire counts for previous driving cycles | events |
| A5 | $0C | Cylinder #4 Misfire counts for last/current driving cycle | events |

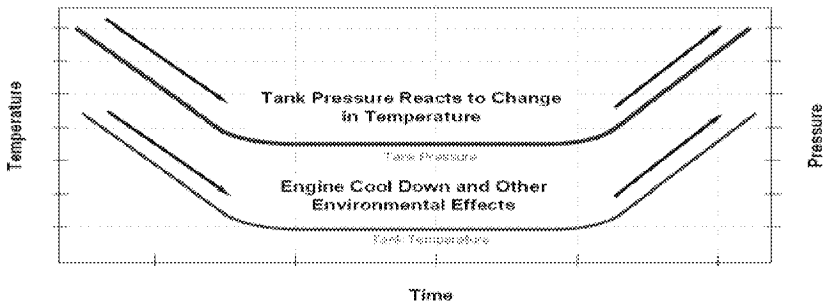
## EVAP System Monitor – Natural Vacuum Leak Detection

This vehicle utilizes an engine off natural vacuum evaporative system integrity check that tests for 0.020" diameter leaks while the engine is off and the ignition key is off. The Natural Vacuum Leak Detection II (NVLD II) evap system integrity check uses a pressure switch to detect evap system leaks.

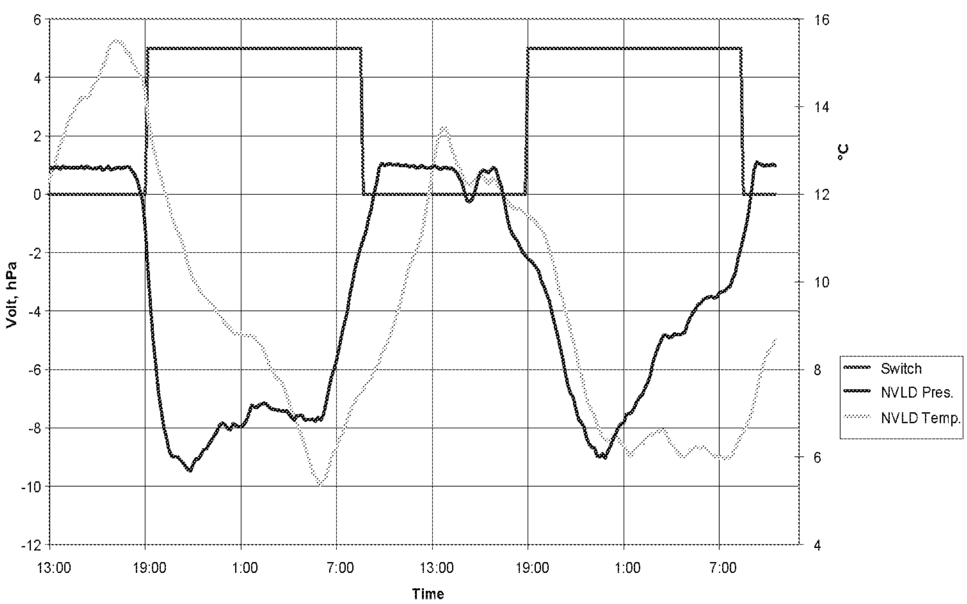



The correlation between pressure and temperature in a sealed system is used to generate a vacuum in the tank when the temperature drops. If a sufficient temperature drop of 8°C (14.5 °F) is detected for a minimum time of 2 hours, the vacuum level in the tank will exceed 0.04 psi and therefore close the NVLD II switch. If the switch closes the system is considered to be leak free. Therefore, if the switch does not close within these conditions, a leak is detected.

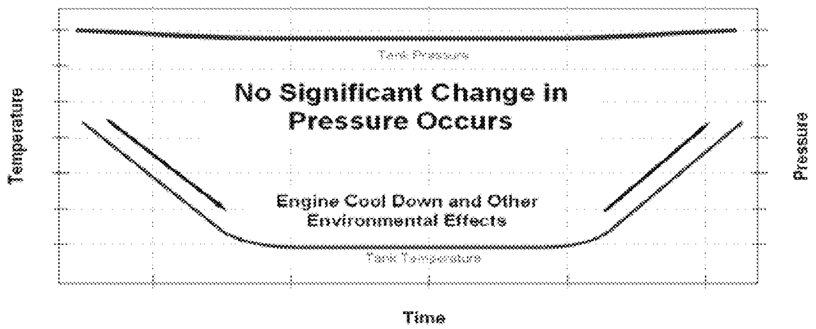
No Leak Switch Closed



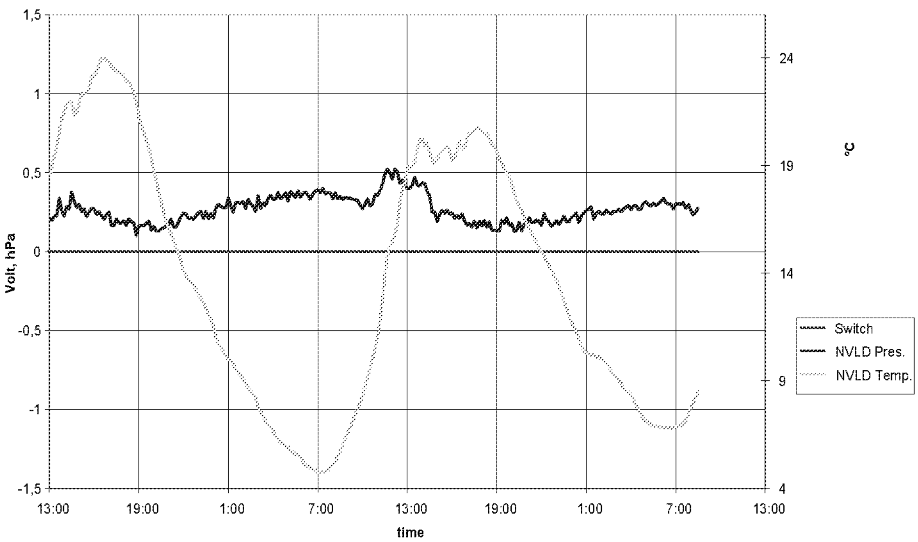

Typical vehicle response without leakage



.020" Leak Switch Open

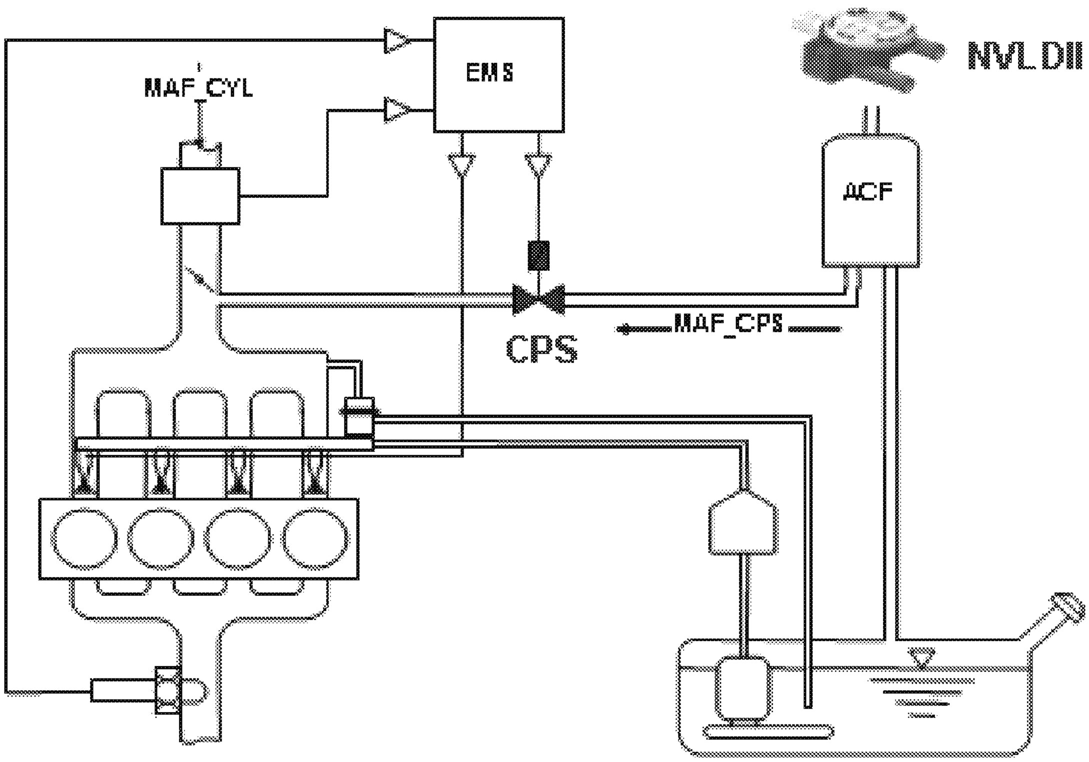



Typical vehicle response with .020" leak



## NVLD II Overview

The NVLD II evaporative system monitor consists of an NVLD II module, the Canister Purge Solenoid (CPS) and software in the ECM that enables/disables the monitor, determines fault status and manages fault code storage, Mode $06 data, Mode $09 data, etc.



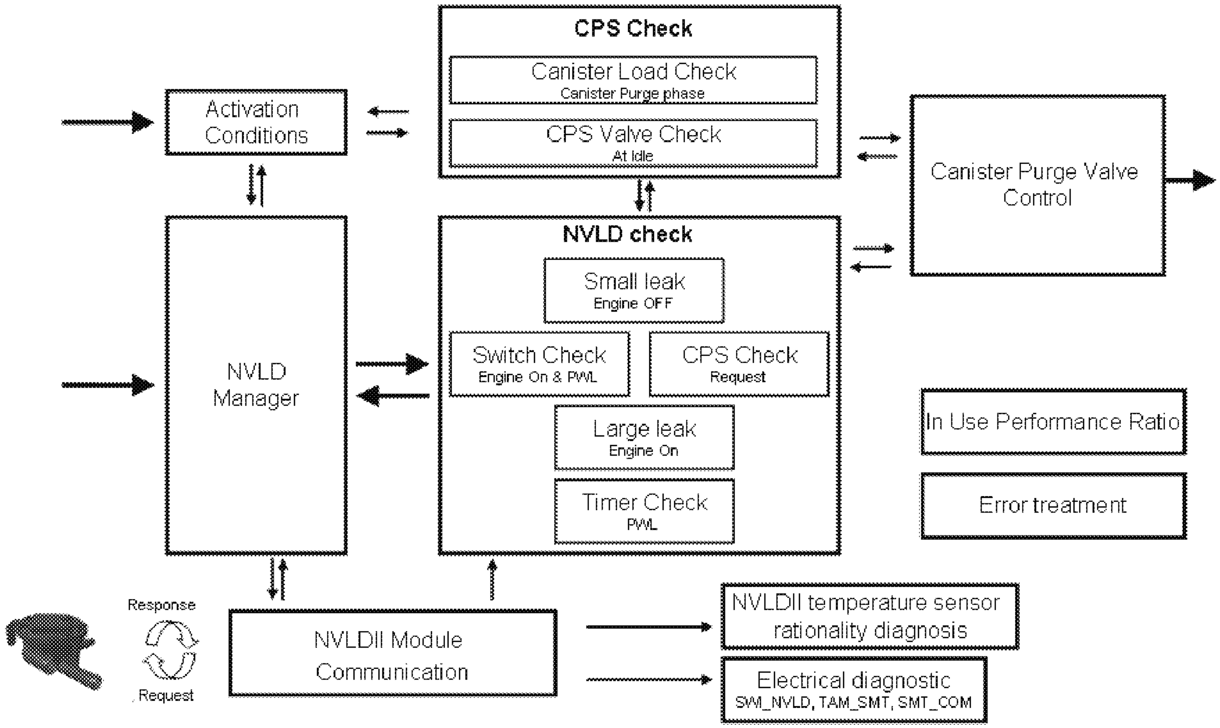

The NVLD II monitor performs a small (0.020") leak check during engine off and a large leak check during engine running. The NVLD II module incorporates a pressure switch and temperature sensor so the monitor also includes a complete series of auxiliary checks to confirm the integrity of the mechanical and electrical components that make up the entire evap monitoring system. The NVLD II module is powered after the ignition key is turned off so that the entire ECM does not have to be powered to perform the engine-off small leak check. This saves a considerable amount of current draw from the battery.

The following functions are managed by the software in the ECM:

- 0.020" small leak detection enablement and fault decision (engine off)
- Large leak/fuel cap off detection enablement and fault decision (engine running)
- Canister purge solenoid (CPS) (electrical/wiring and mechanical rationality)
- NVLD II communications (protocol check and electrical/wiring)

The following functions are managed by the NVLD II module

- NVLD II pressure switch (electrical/wiring and mechanical rationality check)
- NVLD II temperature sensor (rationality and out of range check)
- NVLD II timer (rationality check)


CPS Check
Canister Load Check
Canister Purge phase
CPS Valve Check
At Idle
Activation Conditions
Canister Purge Valve Control
NVLD check
Small leak
Engine OFF
Switch Check
Engine On & PWL
CPS Check
Request
Large leak
Engine On
Timer Check
PWL
NVLD Manager
In Use Performance Ratio
Error treatment
Response
Request
NVLDII Module Communication
NVLDII temperature sensor rationality diagnosis
Electrical diagnostic
SWI_NVLD, TAM_SMT, SMT_COM

## Small leak (0.020") detection algorithm:

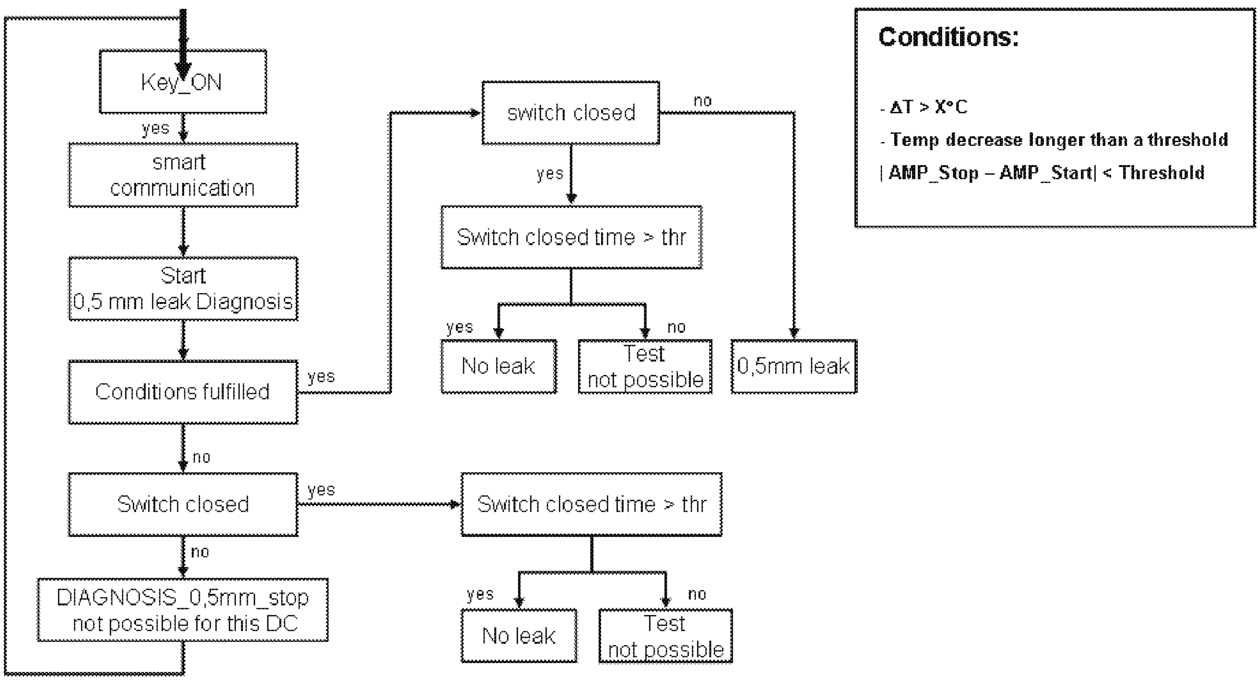
The small leak algorithm is designed to detect a .020" leak in the evaporative purge system as well as a stuck open purge valve. The small leak (0.020" diameter) monitor evaluates the data collected from the NVLD II-module during the ignition key off/engine off phase. At key off, if the pressure switch is closed (vacuum present in tank), then the pressure switch will be monitored for a transition to the open (vacuum not retained) state. This indicates that there may be a leak present and that the engine off evap test must be initiated.

A leak free evap system will generate a vacuum condition in the fuel tank as the fuel cools down. If the pressure switch in the NVLD II module remains closed for a sufficient time (typically 10 minutes), the monitor passes.

If a temperature drop of 8°C was observed over at least 2 hours with no significant increase in fuel tank vacuum since start of the ignition key off/engine off phase, (i.e. the pressure switch has not closed for the minimum time), a small leak is detected. (P0456)

If the diagnostic entry conditions are not met, no diagnostic results are obtained (no call).

The overall evap monitor diagnostics are shown in the diagram below. The 0.020: dia leak monitor data is collected by the NVLD II module during ignition off and evaluated by the ECM during engine-on. The NVLD-II module diagnostics are performed during ignition on and ignition off.




ΔT = difference between actual and maximum temperature value
X°C= temperature decrease criteria to detect very small leak



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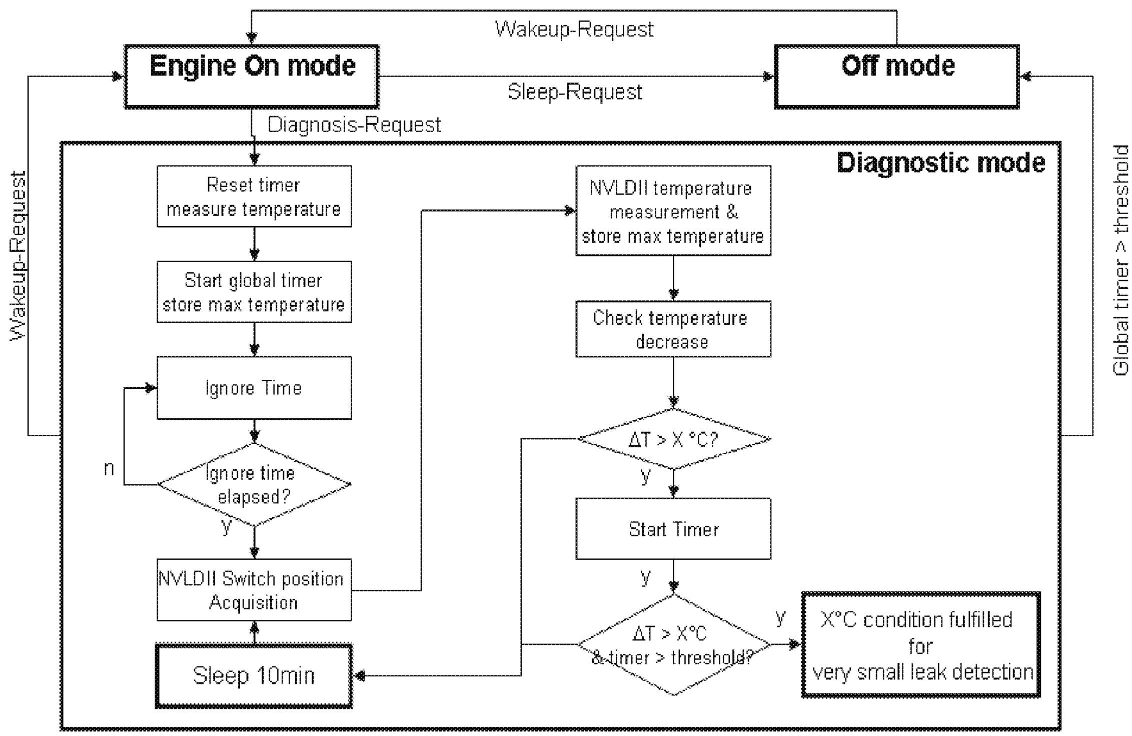
## NVLD II Module Operation

NVLD II module diagnostic operation is divided into three operational modes, which are entered depending on external conditions.

- **Engine On mode:** The NVLD II module receives and responds to a communication request from the ECM. These requests are sent during engine run operation. On a key on event, a Wakeup-Request is sent to establish communication between to NVLD II module and ECM.
- **Diagnostic mode:** At the end of a driving cycle (ECM powerlatch active), the NVLD II module receives a Diagnosis-Request to go into "diagnostic mode" and perform engine-off switch and temperature monitoring for very small leak detection.
- **Off mode:** When diagnostic mode is finished or conditions for very small leak detection are not met, the NVLD II module receives a Sleep-Request and goes into "Off mode";




ΔT = difference between actual and maximum temperature value
X°C= temperature decrease criteria to detect very small leak

Note: ΔT = difference between actual and maximum temperature value

In diagnostic mode, after an initial delay time has elapsed, the temperature and switch position are checked every 10 minutes and two separate conditions for small leak detection are determined by checking if the calibrated temperature difference between the actual temperature and the minimum temperature is met for at least 2 hours. If this occurs, a corresponding condition flag is set.

I

| 0.020” EVAP Monitor Operation: | |
|---|---|
| DTCs | P0456 (0.020” leak) |
| Monitor execution | once per driving cycle for ≥ 0.020” dia leak while engine off |
| Sensors/Components OK | PU029F, PU05A0, P0450, P0451, P0452, P0453, P2025, P2026, P2027, P0444, P0458, P0459, P0497, P0460, P0461, P0462, P0463, P0128, P0116, P0117, P0118, P2227, P2228, P2229, P0072, P0073 |
| Monitoring Duration | Data reported every 10 minutes while engine off |

| Typical 0.020” EVAP monitor entry conditions (vacuum decay and engine off): | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine off (soak) time before previous operating cycle was initiated | 120 minutes | |
| Engine Coolant Temperature at engine shutdown | 48 ° C | |
| Ambient Air Temperature | 4.5 ° C | |
| Engine on time during previous operating cycle | 300 seconds | 5400 seconds |
| Cumulative purge flow during previous operating cycle | 97 grams | |
| Idle ratio | | 30% |
| Fuel Level | 15% | 90% |
| BARO | 75 kPa | |
| Change in Fuel Vapor Temperature over at least a 2 hour engione off time period | 8 ° C | |
| Change on BARO during engine off test | | 10 kPa |
| Engine off  vacuum decay time less than threshold | 70 seconds | |
| NVLD vacuum switch at engine shutdown | On (vacuum present) | |

| Typical 0.020" EVPA monitor malfunction thresholds: |
|---|
| NVLD II pressure switch open for > 24 hours after engine off test condition met |

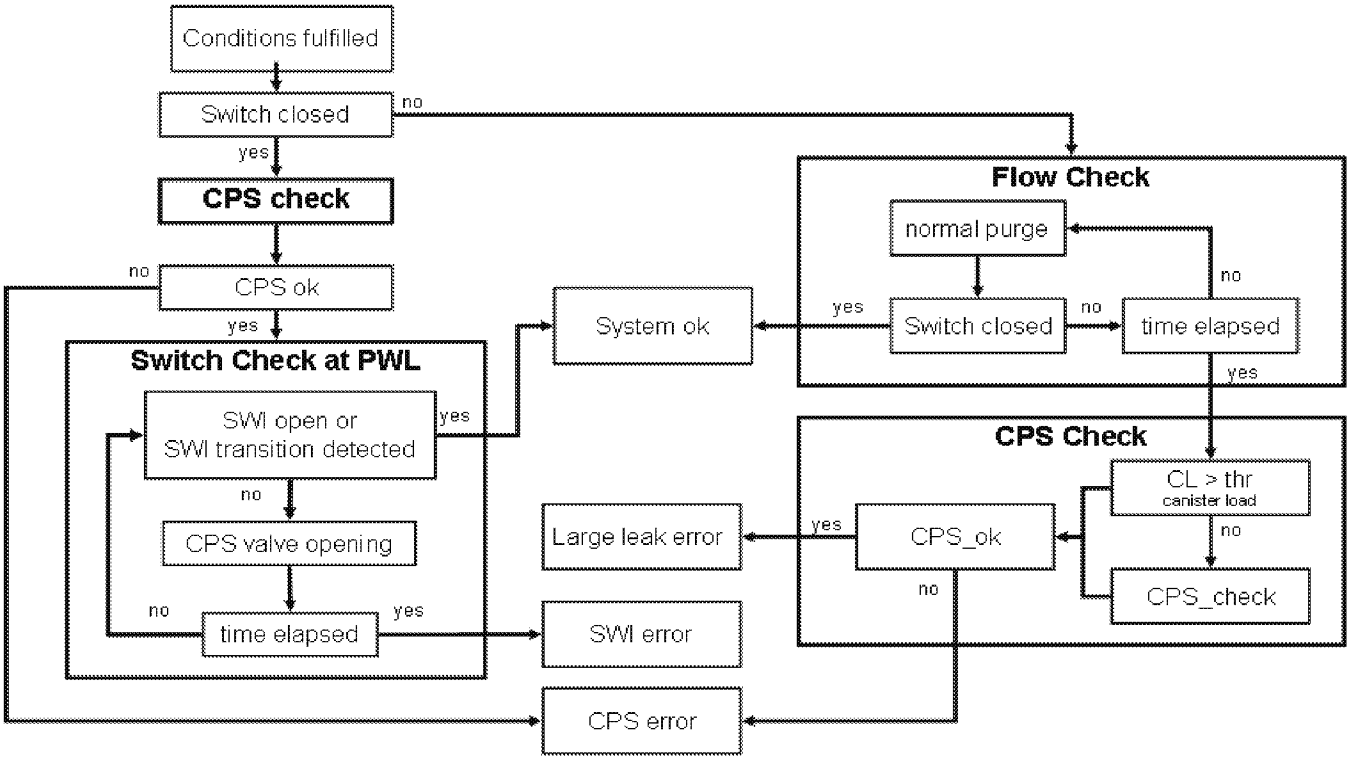
| J1979 NVLD II 0.020" leak monitor Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Comp ID | Description | Units |
| $3C | $A2 | Time after key off for NVLD II switch to remain open for small leak check and max limit | minutes |
| | | | |

## Canister Purge Solenoid, switch and large-leak (0.090") test algorithm:

The large leak monitor is divided into two paths depending on the NVLD II pressure switch position determined at the start of the test. If the switch is already closed, the system is considered not to have a large leak, (as long as the NVLD II switch is not stuck in the closed position). This is determined by opening the CPS during the power-latch phase (i.e. engine stopped) to relieve the vacuum in the tank and force the switch to open. If the switch does not open within a defined time, a mechanical switch error is detected. In order to know that the CPS valve will open and allow the vacuum to be released, the CPS check is done after the switch is detected as closed.

If the switch is open at the start of the diagnostic test, the canister purge solenoid is opened with a defined maximum flow through the CPS valve. As soon as a minimum flow is achieved, the switch position is monitored. If the switch closes within a defined time, the system is considered not to have a large leak. Also the CPS valve must be functioning properly and the NVLD II switch is not stuck in one position.

If the switch does not close, the detection of the large leak (P0455) or CPS valve error (blocked line) (P0497) is complete.



## Canister Purge Solenoid CPS - Flow-check

The canister purge valve plausibility checks ensure that the canister purge valve is able to be open to purge the canister, but due to consistency of the test results, the flow check will not uniquely determine a flow fault from a large leak. Therefore the large leak diagnostic fault (P0455) will be invoked.

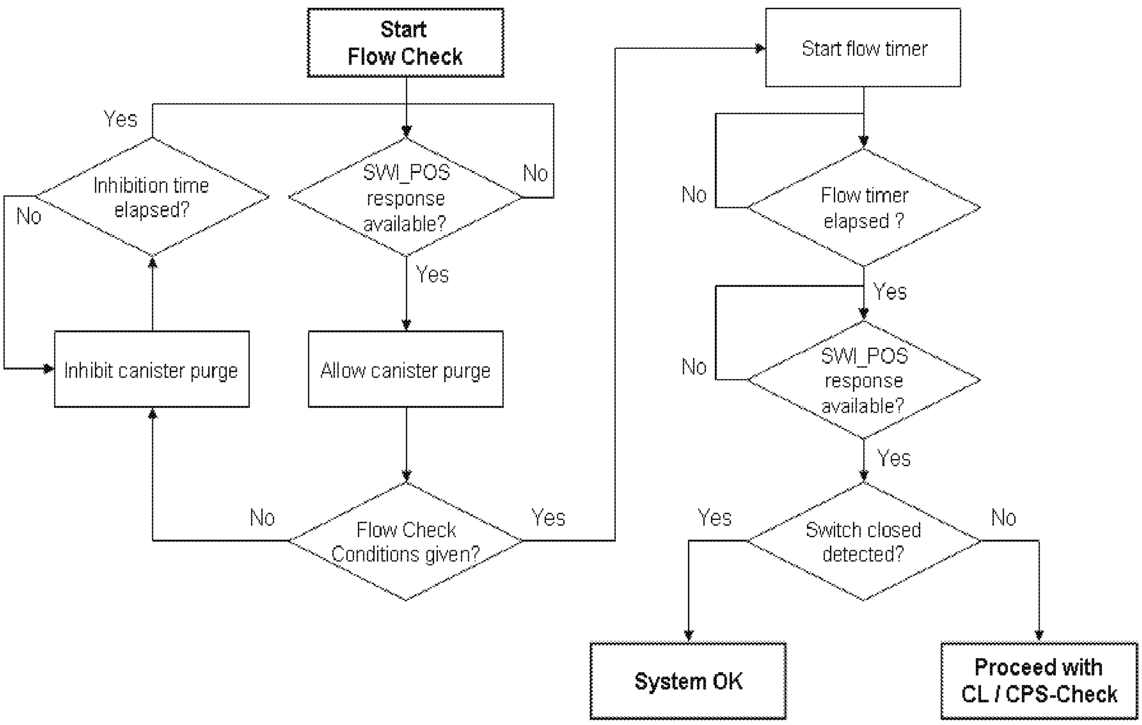
The canister purge valve plausibility checks can be done in three ways:

- When NVLD II module switch closed during large leak test
- When Canister load higher than a threshold during a calibrated time
- With Canister purge valve control (intrusive test).

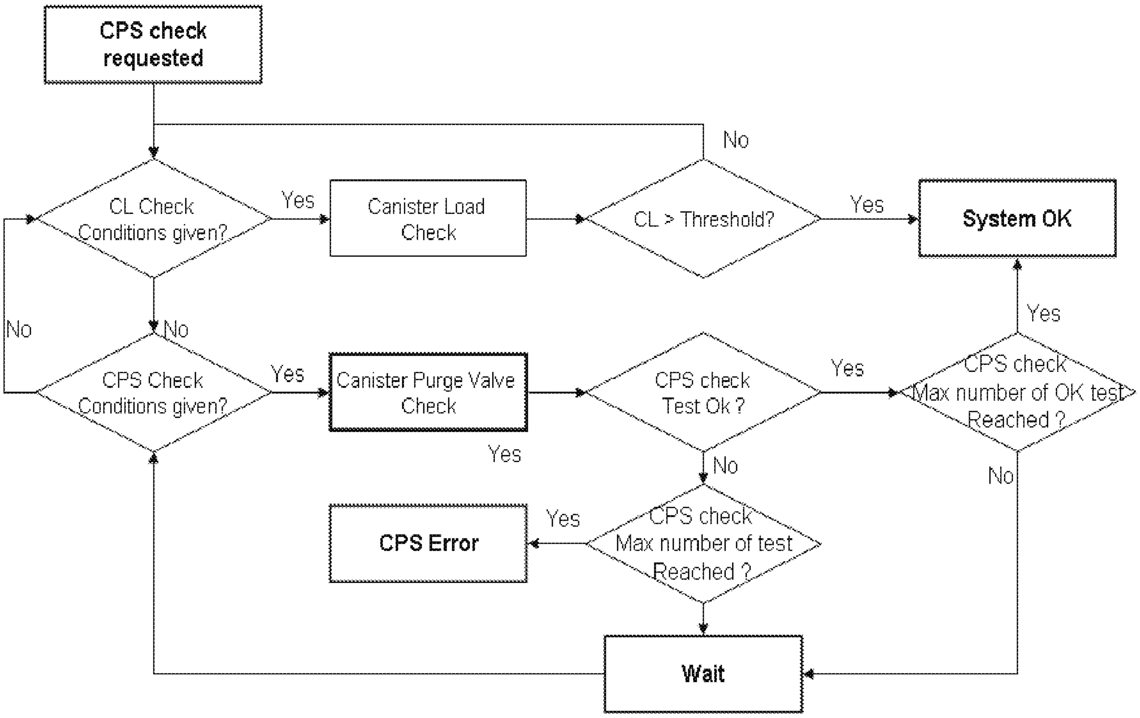
The canister purge valve control can act in via flow request or pwm request. The main difference between the two tests is the following.

- With PWM control CPS check make intrusive test into the ECM functionality and the reaction expected when the CPS valve opens, is engine parameter deviations.
- With FLOW control, CPS check we make non intrusive test into the ECM functionality and the reaction expected when the CPS valve opens is no engine parameter deviations.

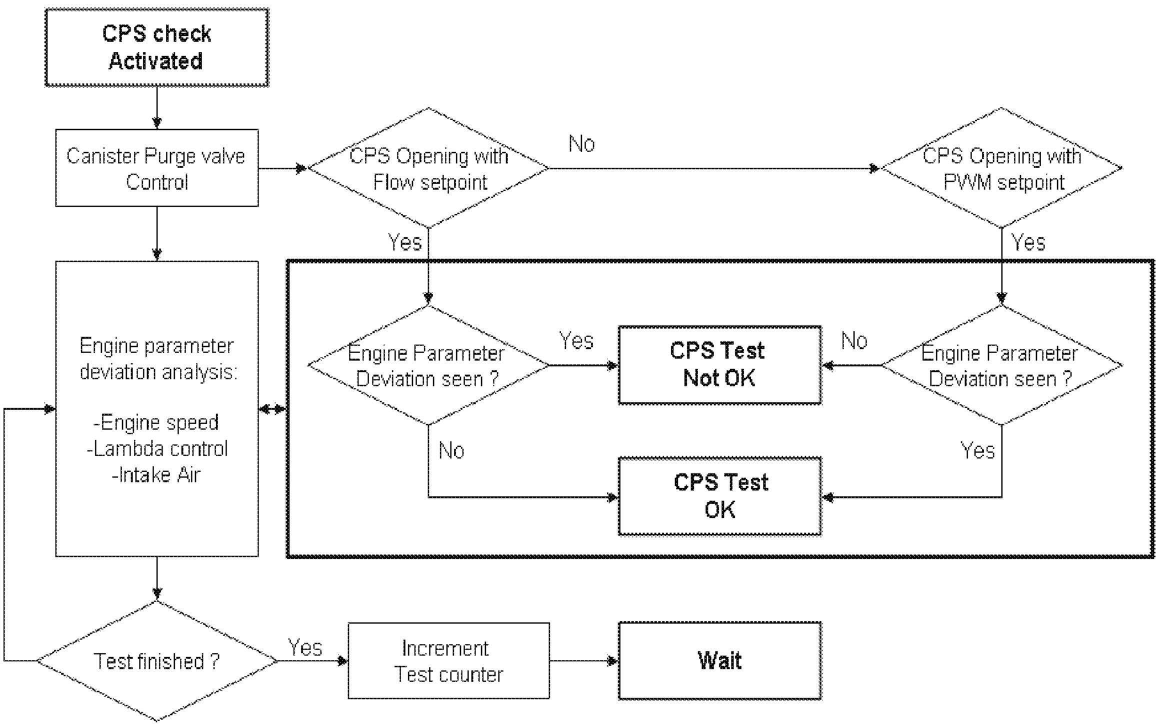
  The canister purge valve control test can be done several times before an error is reported.




Flow check algorithm




Canister Purge valve Functional check algorithm




Canister Purge Valve Check algorithm

| 0.090" Leak/Low Purge Flow Monitor Operation: | |
|---|---|
| DTCs | P0455 (0.090" leak/no purge flow) |
| Monitor execution | once per driving cycle |
| Sensors/Components OK | PU029F, PU05A0, P0450, P0451, P0452, P0453, P0444, P0458, P0459, P0460, P0461, P0462, P0463, P0128, P0116, P0117, P0118, P2227, P2228, P2229, P0072, P0073, P0500 |
| Monitoring Duration | 80 seconds |

| Typical 0.090" Leak/Low Purge Flow monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine run time | 60 seconds | |
| Engine Coolant Temperature | 48 ° C | |
| Ambient Air Temperature | 4.5 ° C | |
| Fuel Fill Level | 15% | 90% |
| BARO | 75 kPa | |
| Stable idle rpm | | 100 rpm |
| Stable idle torque | | 5 Nm |
| Vehicle speed | | 0.6 mph |

| Typical 0.090" Leak/Low Purge Flow monitor malfunction thresholds: |
|---|
| Evaporative emission system pressure switch state open for > 150 sec AND<br>Manifold pressure change > 1.4 kPa AND Manifold pressure min/max delta > 1.4 kPa AND<br>Mass air flow change >0.906 kg/h AND Mass air flow min/max delta >0.906 kg/h AND<br>Air adaptive change >45% AND air adaptive min/max delta >45% AND<br>Engine idle speed change >20 rpm AND Engine idle speed min/max delta >20 rpm AND<br>Idle speed controller change >0.3125 Nm AND Idle speed controller min/max delta > 0.3125 Nm AND<br>Lambda change > 10% AND Lambda min / max delta > 10% |

| J1979 NVLD II 0.090" leak monitor Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Comp ID | Description | Units |
| $3A | $A1 | Time for NVLD II switch to close during large leak check | seconds |
| | | | |

| J1979 NVLD II Purge Flow monitor Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Comp ID | Description | Units |
| $3D | $B0 | Time for NVLD II switch to close during purge flow check | Seconds |
| $3D | $B1 | Air adaption change during intrusive flow check and max limit | percent |
| $3D | $B2 | Lambda change during intrusive flow check and max limit | percent |
| $3D | $B3 | Idle speed change during intrusive flow check and max limit | Rpm |
| $3D | $B4 | Manifold flow change during intrusive flow check and max limit | Kg/h |
| $3D | $B5 | Manifold air pressure change during intrusive flow check and max limit | hPa |
| $3D | $B6 | Idle speed controller change during intrusive flow check and max limit | Nm |

## EVAP System Monitor Component Checks

Additional malfunctions that are to be identified as part of the evaporative system integrity check are as follows:

The Canister Purge Solenoid circuit is checked for opens and shorts (P0444, P0458, P0459)

Note that a CPS that is stuck closed will generate a P0455, and a CPS that is stuck open will generate a P0496.

| Canister Purge Solenoid Check Operation: | |
|---|---|
| DTCs | P0444 – Canister Purge Solenoid open circuit<br>P0458 – Canister Purge Solenoid short to ground<br>P0459 – Canister Purge Solenoid short to battery |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 1 sec to obtain smart driver status |

| Canister Purge Solenoid check entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| P0444 Canister Purge Pulsewidth | 7.81% | 98% |
| P0458 Canister Purge Pulsewidth | | 98% |
| P0459 Canister Purge Pulsewidth | 7.81% | |

| EVAP Pressure Switch Check Operation: | |
|---|---|
| DTCs | P0450 – Evap pressure switch position fault<br>P0452 – Evap pressure switch low<br>P0453 – Evap pressure switch high |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | U029F |
| Monitoring Duration | 30 seconds during engine running, 10 min during engine off |

| EVAP Pressure Switch check malfunction thresholds: |
|---|
| P0450 – Switch value within fail range, > 0.366 V, or < 0.574 V<br>P0452 – Switch position value low < 0.256 V<br>P0453 – Switch position value high > 2.857 V |

| EVAP Pressure Switch Performance Monitor Operation: | |
|---|---|
| DTCs | P0451 - Evap pressure switch performance |
| Monitor execution | once per driving cycle |
| Sensors/Components OK | |
| Monitoring Duration | 80 seconds |

| EVAP Pressure Switch Performance monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine run time | 60 seconds | |
| Engine Coolant Temperature | 48 ° C | |
| Ambient Air Temperature | 4.5 ° C | |
| Fuel Fill Level | 15% | 99.6% |
| BARO | 75 kPa | |
| Time at Idle | 4 seconds | |
| Stable idle rpm | | 100 rpm |
| Stable idle torque | | 5 Nm |
| Vehicle speed | | 0.6 mph |

| EVAP Pressure Switch Performance check malfunction thresholds: |
|---|
| P0451 – "IF Switch closed at engine start AND Switch closed during a passing CPS check (P0496)"<br>OR "IF Switch open at engine start AND Switch open during high canister purge duty cycle"<br>OR "IF Switch closed at ECU power latch AND Switch closed after power latch CPS cycle" |

| EVAP Fuel Temperature Sensor Check Operation: | |
|---|---|
| DTCs | P2026 – EVAP Fuel Temperature Sensor Circuit Low<br>P2027 – EVAP Fuel Temperature Sensor Circuit High |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | U029F, U05A0 |
| Monitoring Duration | 0.10 seconds |

| EVAP Fuel Temperature Sensor check malfunction thresholds: |
|---|
| P2026 – sensor voltage > 4.85 V<br>P2027 – sensor voltage < 0.18 V |

| EVAP Pressure Switch Performance Monitor Operation: | |
|---|---|
| DTCs | P2025 – EVAP Fuel Temperature Sensor Performance |
| Monitor execution | once per driving cycle |
| Sensors/Components OK | P0116, P0117, P0118, P0119, P0111, P0112, P0113, P0072, P0073, P2610, P2229, P2228, P2227, U029F, |
| Monitoring Duration | 80 seconds |

| EVAP Pressure Switch Performance monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine Off Time from previous drive cycle | 400 minutes | |
| BARO | 75 kPa | |
| Ambient Air Temperature | 4.5 ° C | |
| Fuel tank level | 15% | 90% |
| Engine Coolant Temperature | 48 ° C | |

| EVAP Pressure Switch Performance check malfunction thresholds: |
|---|
| EVAP Fuel Temp sensor temperature change within 10 minutes > 20 deg C OR<br>abs value of the difference between EVAP Fuel Temp and IAT at cold start > = 15 deg C AND<br>abs value of the difference between EVAP Fuel Temp and ECT at cold start > = 15 deg C |

| NVLD II Communication Check Operation: | |
|---|---|
| DTCs | U029F - Lost Communication with EVAP Leak Detection Module<br><br>U05A0 - Invalid Data Received form EVAP Leak Detection Module |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | 150 msec for U029F, 300 msec for U05A0 |

| NVLD II Communication check malfunction thresholds: |
|---|
| U029F - Invalid Response from NVLD module OR |
| Time out error on NVLD module communication line OR |
| Open circuit fault on NVLD module communication line OR |
| Short circuit to ground fault on NVLD module communication line OR |
| Short circuit to positive fault on NVLD module communication line |
| U05A0 - Leak Detection Control module reset occurred (power loss) OR |
| Difference between Leak Detection Control module timer and ECU internal timer > 2.0 sec |

The ECM receives the FLI signal via the CAN data link from the instrument cluster. The Fuel Level Input is checked for out of range values, opens and shorts. If the FLI signal is stuck, a P0460 is set. The ECM calculates the amount of fuel being consumed by accumulating fuel pulse width. If the there is an insufficient corresponding change in fuel tank level, a P0460 DTC is set. Finally, the Fuel Level Input is checked for noisy readings. If the FLI input changes rapidly, a P0461 DTC is set.

| Fuel Level Input Check Operation: | |
|---|---|
| DTCs | P0460 – Fuel Level Input Circuit Erratic<br>P0461 – Fuel Level Input Circuit Stuck<br>P0462 – Fuel Level Input Circuit Low (short to ground/open circuit)<br>P0463 – Fuel Level Input Circuit High (short to power) |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | FLI errors |
| Monitoring Duration | 12.7 sec for circuit tests, 10 sec for noisy test, 120 miles for stuck test |

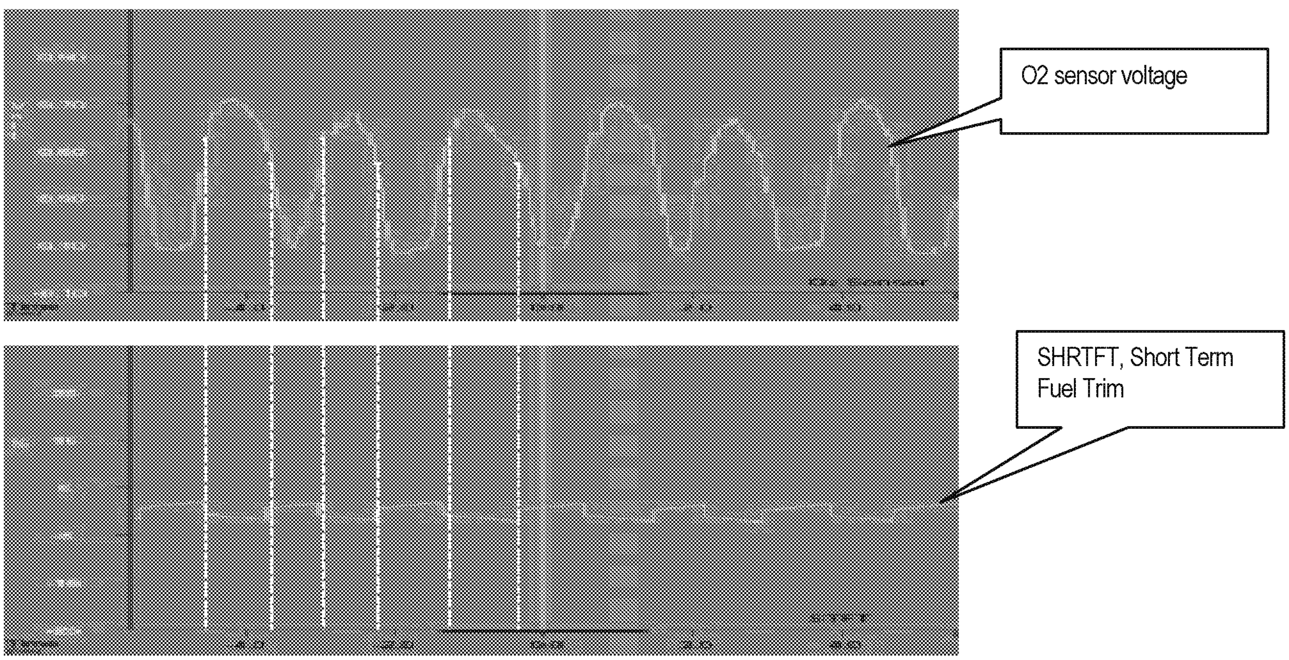
| Typical Fuel Level Input check malfunction thresholds: |
|---|
| P0462 (Fuel Level Input Circuit Low): < 0.01 V ratio |
| P0463 (Fuel Level Input Circuit High): > 0.9902 V ratio |
| P0460 (Fuel Level Input Stuck): < 0.4L change after 1.0 L has been consumed. |
| P0461 (Fuel Level Input Gradient): > 0.5 L change over a 660 msec sample period |

## Fuel System Monitor

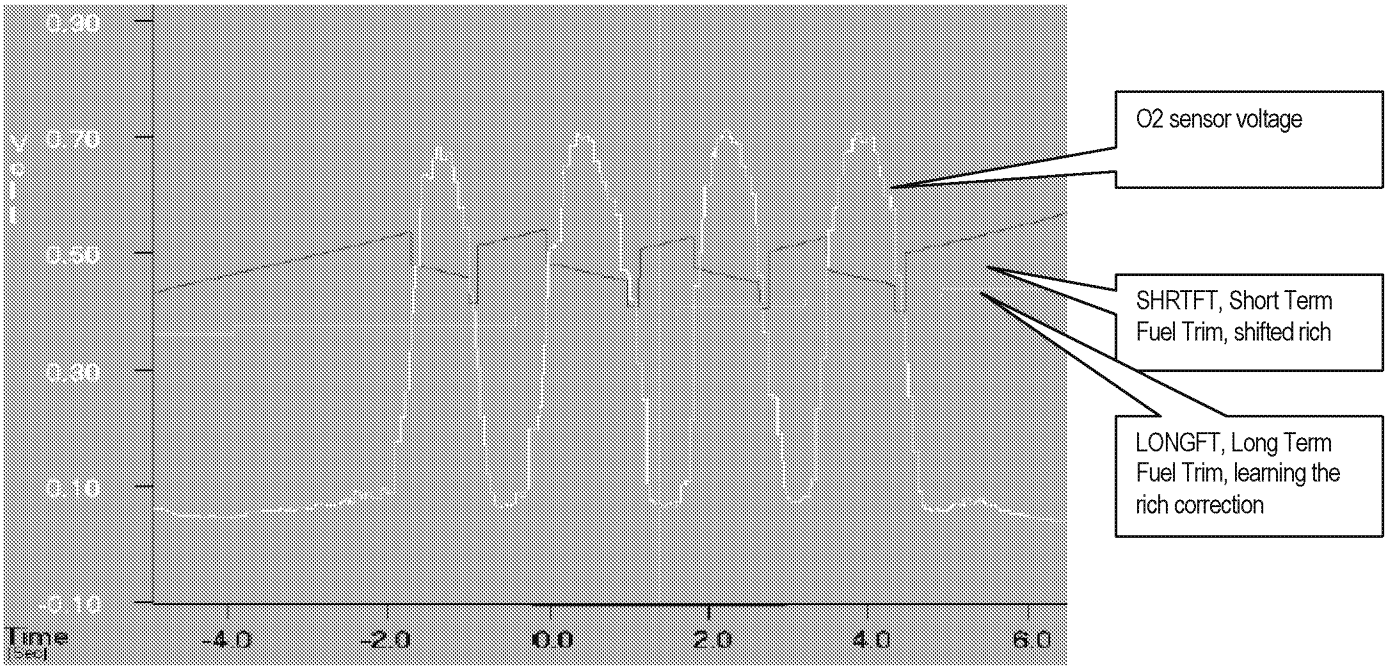
The closed loop fuel strategy uses O2 sensors for feedback. The fuel equation includes short and long term fuel trim modifiers:

A conventional O2 sensor (not a wide-range sensor) can only indicate if the mixture is richer or leaner than stoichiometric. During closed loop operation, short term fuel trim values are calculated by the ECM using oxygen sensor inputs in order to maintain a stoichiometric air/fuel ratio. The ECM is constantly making adjustments to the short term fuel trim, which causes the oxygen sensor voltage to switch from rich to lean around the stoichiometric point. As long as the short term fuel trim is able to cause the oxygen sensor voltage to switch, a stoichiometric air/fuel ratio is maintained.

When initially entering closed loop fuel, SHRTFT starts 1.0 and begins adding or subtracting fuel in order to make the oxygen sensor switch from its current state. If the oxygen sensor signal sent to the ECM is greater than 0.45 volts, the ECM considers the mixture rich and SHRTFT shortens the injector pulse width. When the cylinder fires using the new injector pulse width, the exhaust contains more oxygen. Now when the exhaust passes the oxygen sensor, it causes the voltage to switch below 0.45 volts, the ECM considers the mixture lean, and SHRTFT lengthens the injector pulse width. This cycle continues as long as the fuel system is in closed loop operation.




As fuel, air, or engine components age or otherwise change over the life of the vehicle, the adaptive fuel strategy learns deviations from stoichiometry while running in closed loop fuel. Corrections are only learned during closed loop operation, and are stored in the ECM as long term fuel trim values (LONGFT). They may be stored into a rpm/load table. LONGFT values are only learned when SHRTFT values cause the oxygen sensor to switch. If the average SHRTFT value remains above or below stoichiometry, the ECM "learns" a new LONGFT value, which allows the SHRTFT value to return to an average value near 1.0. LONGFT values are stored in Keep Alive Memory as a function of air mass. The LONGFT value displayed on the scan tool is the value being used for the current operating condition.

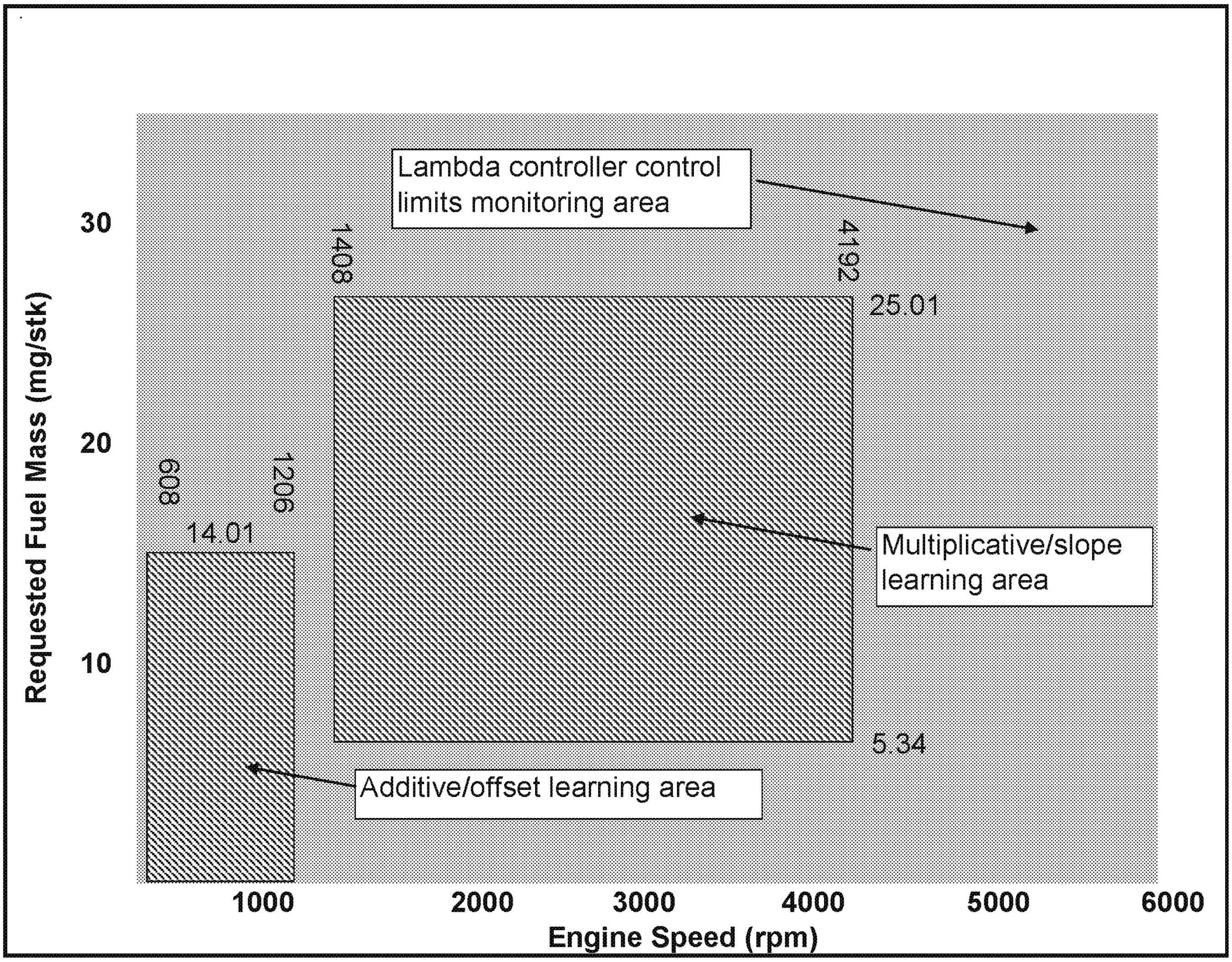



As components continue to change beyond normal limits or if a malfunction occurs, the long-term fuel trim values will reach a calibratable rich or lean limit where the adaptive fuel strategy is no longer allowed to compensate for additional fuel system changes. Long term fuel trim corrections at their limits, in conjunction with a calibratable deviation in short term fuel trim, indicate a rich or lean fuel system malfunction.

The fuel system monitor has two distinct monitoring paths. The fast path is used to determine if the lambda controller is unable to maintain fuel control. In this case, the controller has reached the minimum or maximum control limits (lack of switching) and a DTC is stored. The slow path is used when normal fuel adaption is taking place on a system under normal lambda control. If the fuel adaption values reach the minimum or maximum adaption limits, a DTC is stored. The fuel monitor learns both a slope and offset term. The additive/offset term is learned at idle while the slope/multiplicative term is learned at higher loads and engine speeds.

Note that Positive Crankcase Ventilation monitoring occurs at idle. A disconnected PCV hose will result in a lean condition at idle that will be detected by the fuel monitor.

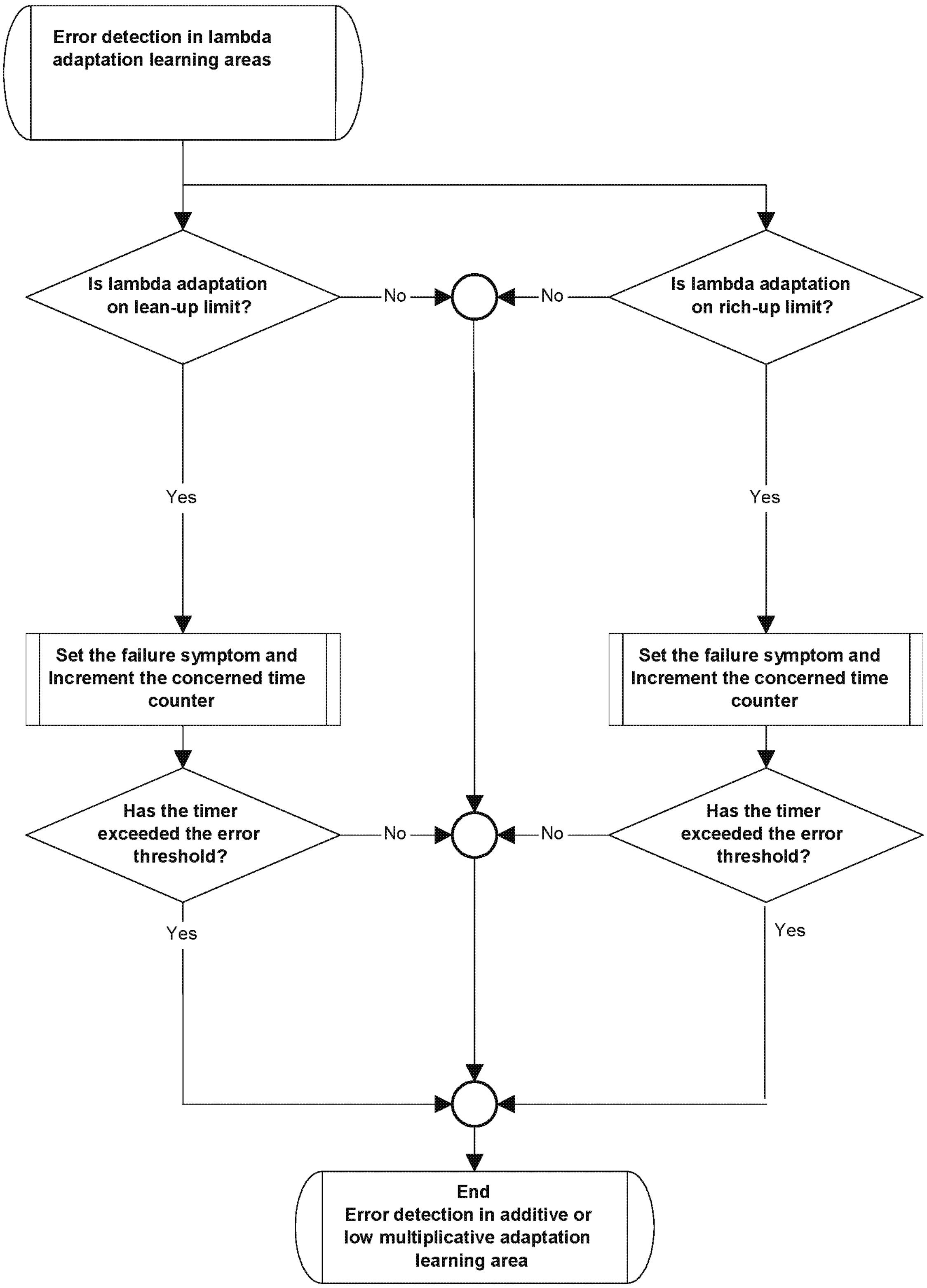
The diagram below shows the calibratable areas where fuel monitor learning takes place during closed loop fuel control.



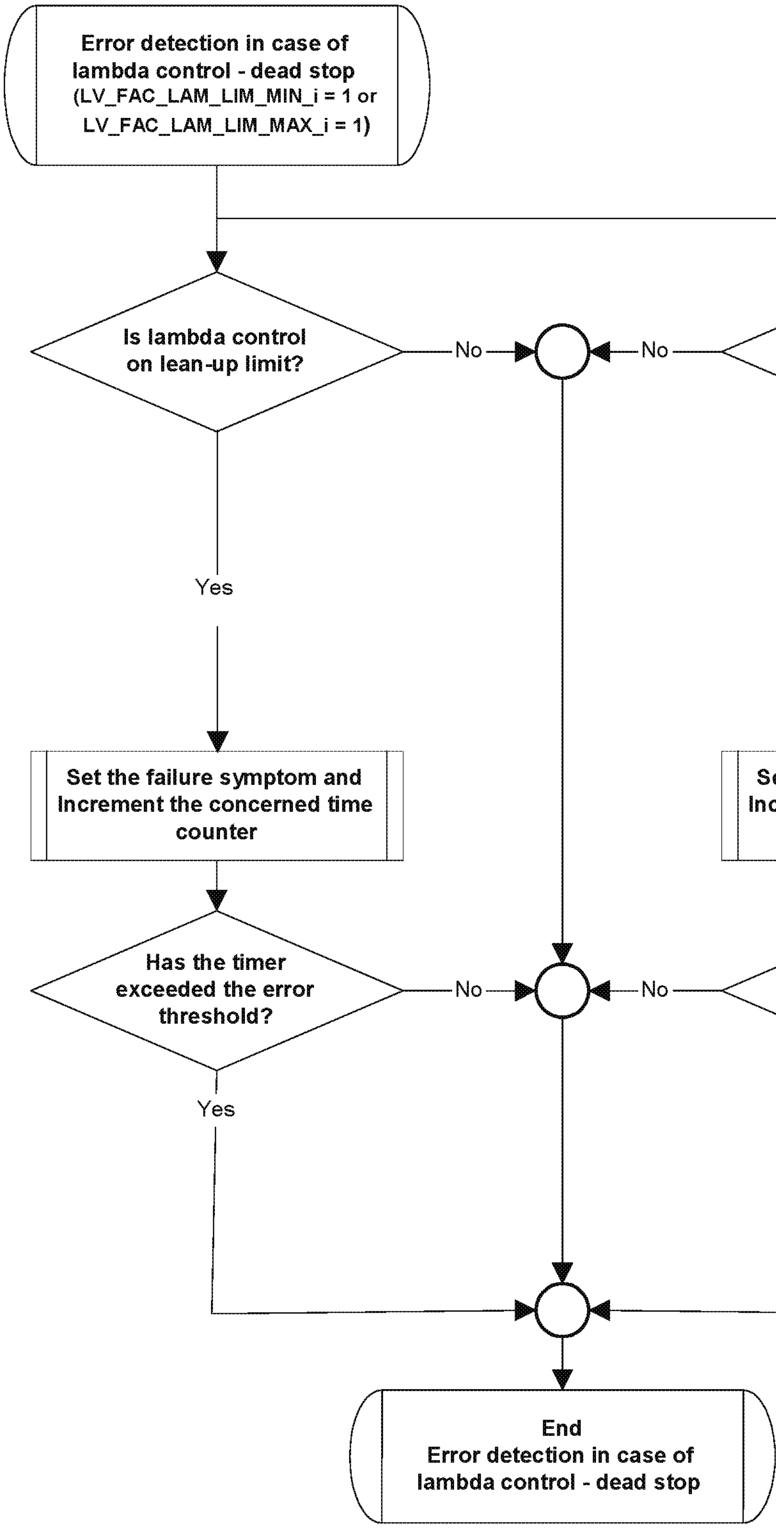

**Similar Conditions**

When the ECM recognizes a failure in the misfire or fuel systems, the software stores the conditions present when the fault occurred. These conditions recorded include engine speed, engine load (MAF), and warm up status of the first event that resulted in the storage of a DTC. These stored conditions are referred to as similar conditions. If the similar conditions are met without a failure in the misfire or fuel system, a flag is set to 1 which allows the driving cycle counter for that failure to decrement. Any misfire or fuel system DTCs are erased if similar conditions are not encountered during the next 80 driving cycles immediately following the initial detection of the malfunction. The MIL is extinguished after three consecutive driving cycles in which similar conditions have been encountered without exceeding the misfire or fuel system diagnostic thresholds.

# Fuel Monitor Adaption Monitoring



## Fuel Monitor Lambda Controller Monitoring



| Fuel Monitor Operation: | |
|---|---|
| DTCs | P0171 System Lean<br>P0172 System Rich |
| Monitor execution | continuous while in closed loop fuel |
| Monitor Sequence | NA |
| Sensors OK | CPS, ECT, MAF, Misfire, IAT, TPS, HO2S, CAM, TPS, CRK, Injectors , AMP, AAT, VVT |
| Monitoring Duration | continuous |

| Typical fuel monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine running and lambda closed loop | | |
| BARO | 75 kPa | |
| Mass Air Flow | 65 mg/stk | |
| Engine Speed | 608 rpm | redline |
| Engine Coolant Temperature | 69.75 $^{o}$C | |
| Intake Air Temperature | -10.5 $^{o}$C | |
| Ambient Air Temperature | -10.5 $^{o}$C | |
| Engine speed for offset lambda adaptation | 608 rpm | 1206 rpm |
| Fuel mass for offset lambda adaptation | | 14.01 mg/stroke |
| Engine speed for multiplicative lambda adaptation | 1408 rpm | 4192 rpm |
| Fuel mass for multiplicative lambda adaptation | 5.34 mg/stroke | 25.01 mg/stroke |

**Typical fuel monitor malfunction thresholds:**

P0171

Lambda controller at maximum limit, short term fuel trim > 39.99% for > 40 sec OR

Lambda adaptation > 25% for > 20 sec

P0172

Lambda controller at minimum limit, short term fuel trim < -39.99% for > 60 sec OR

Lambda adaptation < - 25% for 20 sec

### Upstream Oxygen Sensor Monitoring - Switching Sensor

The upstream oxygen sensor circuit monitor detects if the HO2S sensor voltage is above or below a calibratable threshold or if it is not active, (lack of switching) or stuck at the bias voltage.

The upstream oxygen sensor monitor detects if the HO2S signal circuit voltage is:

> Shorted to ground or an air leak is present (low signal),
>
> Signal circuit voltage is high (high signal),
>
> Open circuit causing the signal circuit voltage to be inactive or stuck at the bias voltage.

The open circuit detection strategy is described below

Open Circuit Check

This check detects if the HO2S signal circuit is not active (lack of switching) or stuck at the bias voltage at the beginning of the driving cycle. This check allows the service technician to find the root cause of the upstream HO2S sensor "not ready for closed loop”. If the "open circuit check" stores a DTC (P0130) then an additional DTC is also stored automatically (P016A ) - O2 Sensor Not Ready (Bank 1 Sensor 1)).

This additional check is performed because there are two different possible root causes for this symptom at engine start. The upstream signal voltage can be inactive (stuck at the bias voltage) because of an open circuit, or because of a weak HO2S heater. These cases are described below:

Case 1: HO2S Open Circuit at engine start

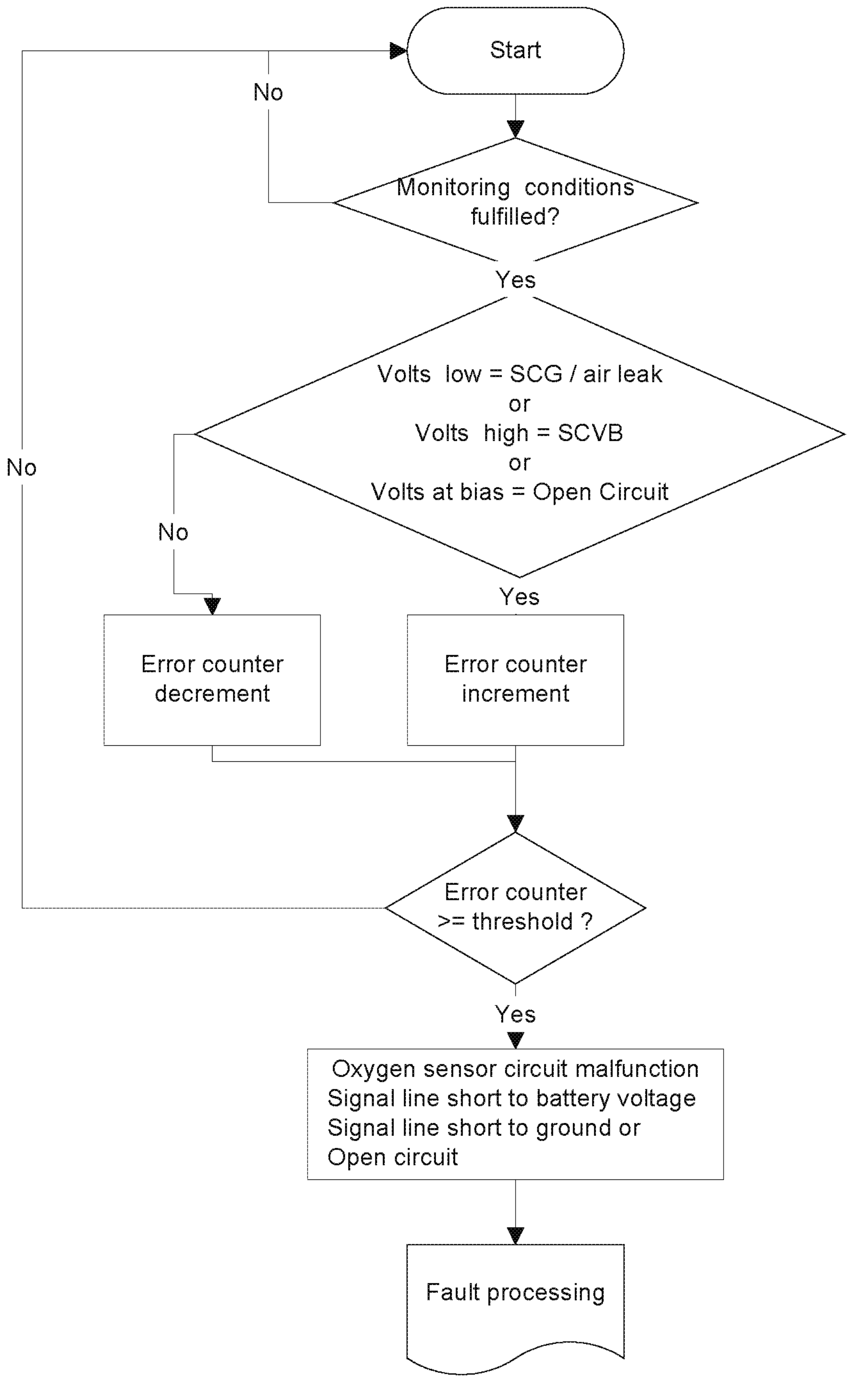
An open circuit power integral starts and activates the open circuit diagnosis to check if a real open circuit is present or if the P016A was set because of a weak O2 sensor heater.

If the power integral exceed its limit, the signal is checked again. If the signal voltage is still stuck at the bias voltage and the internal resistance is above a calibrated limit, a P0130 is stored for an open circuit.

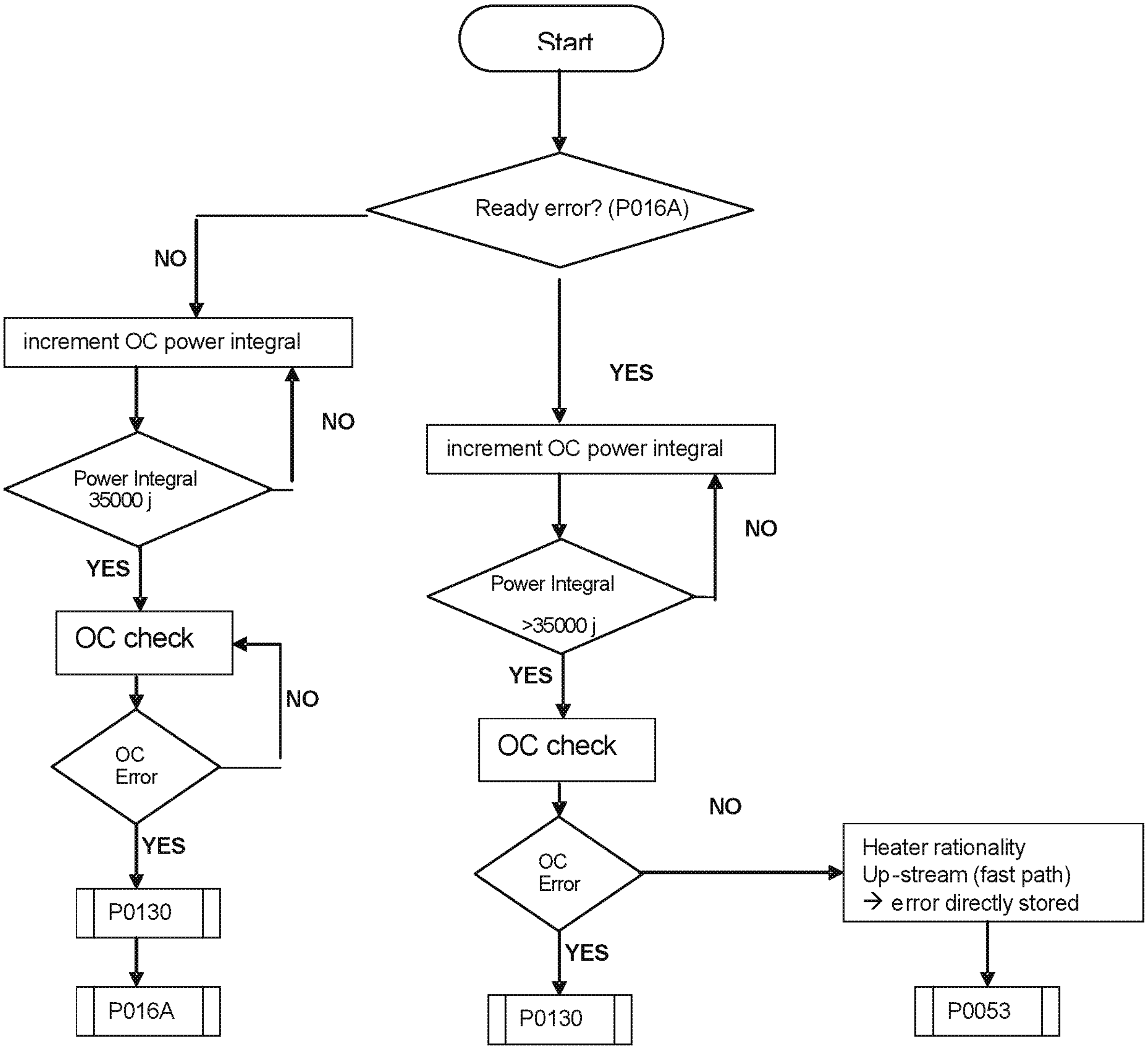
Case 2: HO2S heater low performance at engine start

The open circuit power integral starts and the signal is checked again. The power integral is calibrated based on low activity of the signal voltage with a weak heater. After the power integral exceeds its limit, and the upstream voltage is outside the open circuit limits, if no real open circuit present, the P0053 for the heater rationality upstream is stored.

Upstream HO2S Circuit Check



Upstream HO2S Open Circuit and Heater Rationality Check



| HO2S11 circuit check operation: | |
|---|---|
| DTCs | P0130 – HO2 circuit open (Bank 1, Sensor 1)<br>P0131 – HO2 circuit low voltage (Bank 1, Sensor 1)<br>P0132 – HO2 circuit high voltage (Bank 1, Sensor 1) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | HO2S (P0131, P0132, P0133, P0134, P2297, P2A00), HO2S heaters (P0030, P0031, P0032), MAF (P0101, P0102, P0103) |
| Monitoring Duration | 12.7, 20, or 50 seconds to register a malfunction |

| Typical HO2S11 circuit check entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Stuck above lean voltage limit (P0130 only) | 0.35 volts | |
| Stuck below rich voltage limit (P0130 only) | | 0.5 volts |
| Time stuck (P0130 only) | 50 seconds | |
| Closed loop fuel control (P0131 only) | | |
| Exhaust gas temp (P0131 only) | | 799.97 °C |
| Mass Air Flow (P0131 only) | 6 kg/hr | |
| Time stuck at low voltage (P0131 only) | 20 seconds | |
| Oxygen sensor internal resistance (P0131 only) | | 2 ohms |
| Integrated mass air flow after purge solenoid closed (P0131 only) | 30 g | |
| Time stuck at high voltage (P0132 only) | 12.7 seconds | |

| Typical HO2S11 circuit check malfunction thresholds: |
|---|
| P0130 |
| O2 sensor resistance ≥ 50000 ohms, voltage stuck between 0.35 and 0.5 volts |
| P0131 |
| O2 sensor resistance < 2 ohms and O2 sensor voltage stuck at < .009 volts |
| P0132 |
| O2 sensor voltage stuck above 1.1volts |

## Upstream Oxygen Sensor Slow Response Monitor - Switching Sensor

A fuel control routine drives the air/fuel ratio around stoichiometry at a calibratable frequency and magnitude. This produces a predictable oxygen sensor signal amplitude and duration used to evaluate the response time and frequency response of the sensor.

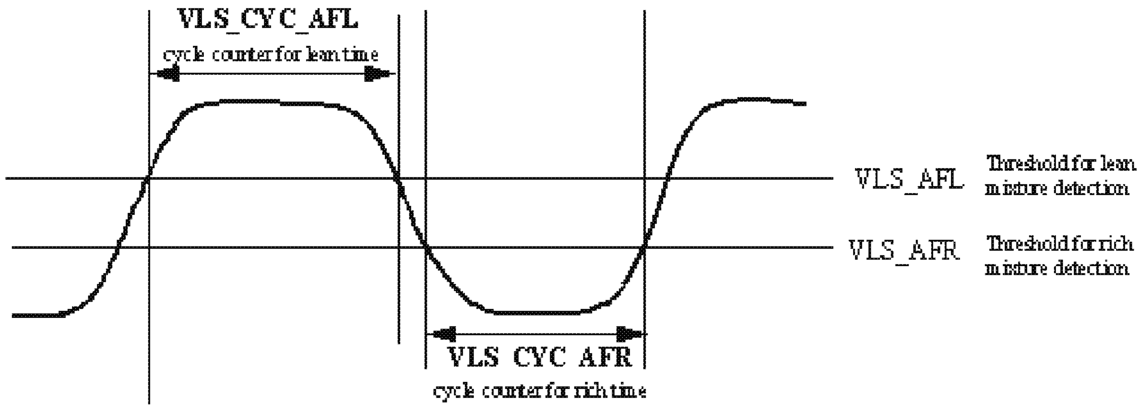
At each cycle, the lean and the rich duration are measured and accumulated separately. After a calibrated number of cycles are exceeded, the accumulated lean and rich durations and periods are compared to the expected durations and periods.

Actual rich to lean switch time is compared to expected rich to lean switch time (as a function of MAF)

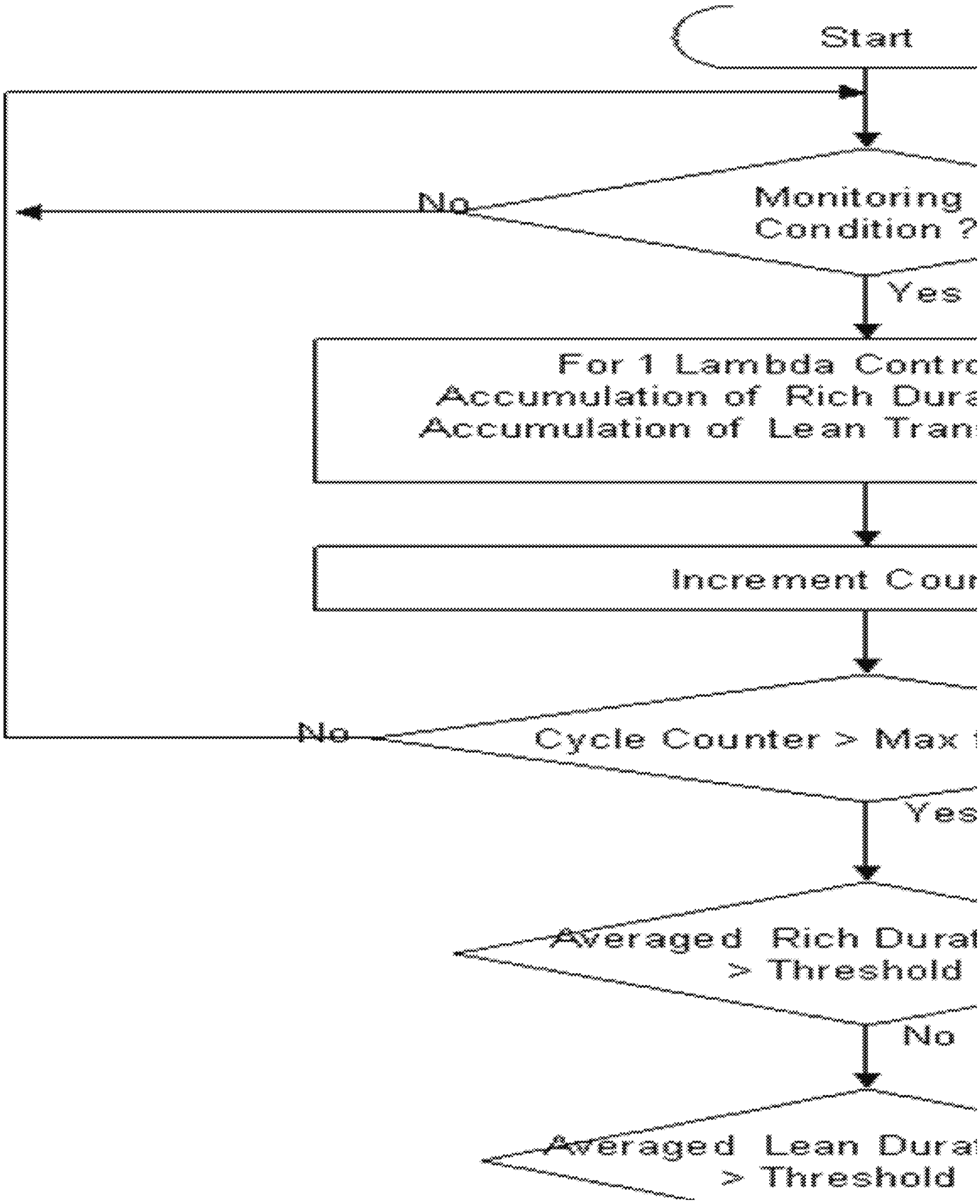
Actual lean to rich switch time is compared to expected lean to rich switch time (as a function of MAF)

Actual rich to lean switch period is compared to expected rich to lean switch period (as a function of MAF & RPM)

Actual lean to rich switch period is compared to expected lean to rich switch period (as a function of MAF & RPM)



Upstream HO2S Slow Response Check



| HO2S11 “Signal Dynamics – Slow Response” Operation: | |
|---|---|
| DTCs | P0133 O2 Sensor Circuit Slow Response (Bank 1 Sensor 1)<br>P0134 O2 Sensor Circuit No Activity Detected (Bank 1 Sensor 1) |
| Monitor execution | Once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | MAF, HO2S, ECT, HO2S heater, CPS |
| Monitoring Duration | 12.7 to 18 seconds to register a malfunction |

| Typical HO2S11 response rate entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Exhaust gas temperature | 399 °C | |
| Engine coolant temperature | 50.25 °C | |
| Engine speed | 1504 rpm | 300 rpm |
| Mass air flow | 25 kg/h | 350 kg/h |
| Number of rich/lean cycles in closed loop (P0134 only) | 50 | |
| Air fuel lean / air fuel rich cycle time (P0134 only) | | 1 s |

**Typical HO2S11 response rate malfunction thresholds:**

P0133

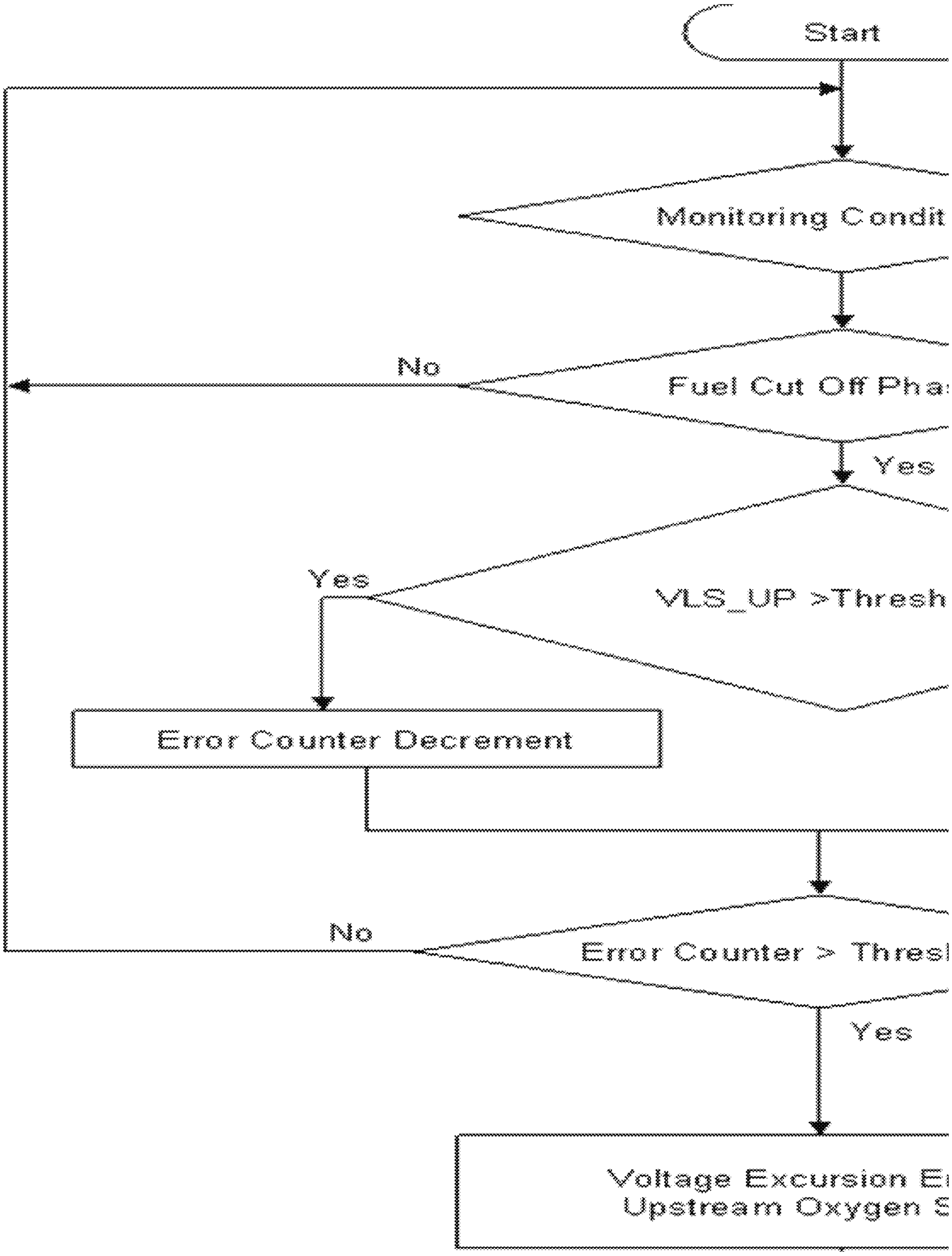
Frequency Check - Actual R/L or L/R switch period compared to expected switch period: > 1.75

P0134

Sensor signal voltage amplitude difference:: < 0.3 V

| J1979 HO2S11 Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description | Units |
| $01 | $81 | Signal voltage amplitude difference | Volts |
| $01 | $83 | Difference between lean and rich frequency ratios | None |
| $01 | $86 | Actual switch period compared to expected switch period for rich time | None |
| $01 | $87 | Actual switch period compared to expected switch period for lean time | None |

Up-Stream Oxygen Sensor Rationality during Fuel Cut-Off



| HO2S11 Out of Range during DFCO Operation: | |
|---|---|
| DTCs | P2297 – O2 Sensor Out of Range During Deceleration ( Bank 1 Sensor 1 ) |
| Monitor execution | Once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | MAF (P0102, P0103), HO2S (P0130, P0131, P0132, P0133, P0134, P2A00), HO2S heater (P0053,P0030, P0031, P0032), CPS (P0458, P0444, P0459, P0497) |
| Monitoring Duration | 3 seconds to register a malfunction |

| Typical HO2S11 Out of Range during DFCO entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| O2 sensor heater | on | |
| Decel Fuel Cut Out (DFCO) active | | |
| Mass air flow | 15 g | 40 g |
| Mass Air Flow during DFCO > Mass Air Flow during DFCO from last recurrence | Yes | |

| Typical HO2S11 Out of Range during DFCO malfunction thresholds: |
|---|
| P2297<br><br>Upstream O2 sensor voltage during DFCO: > 0.15 V |

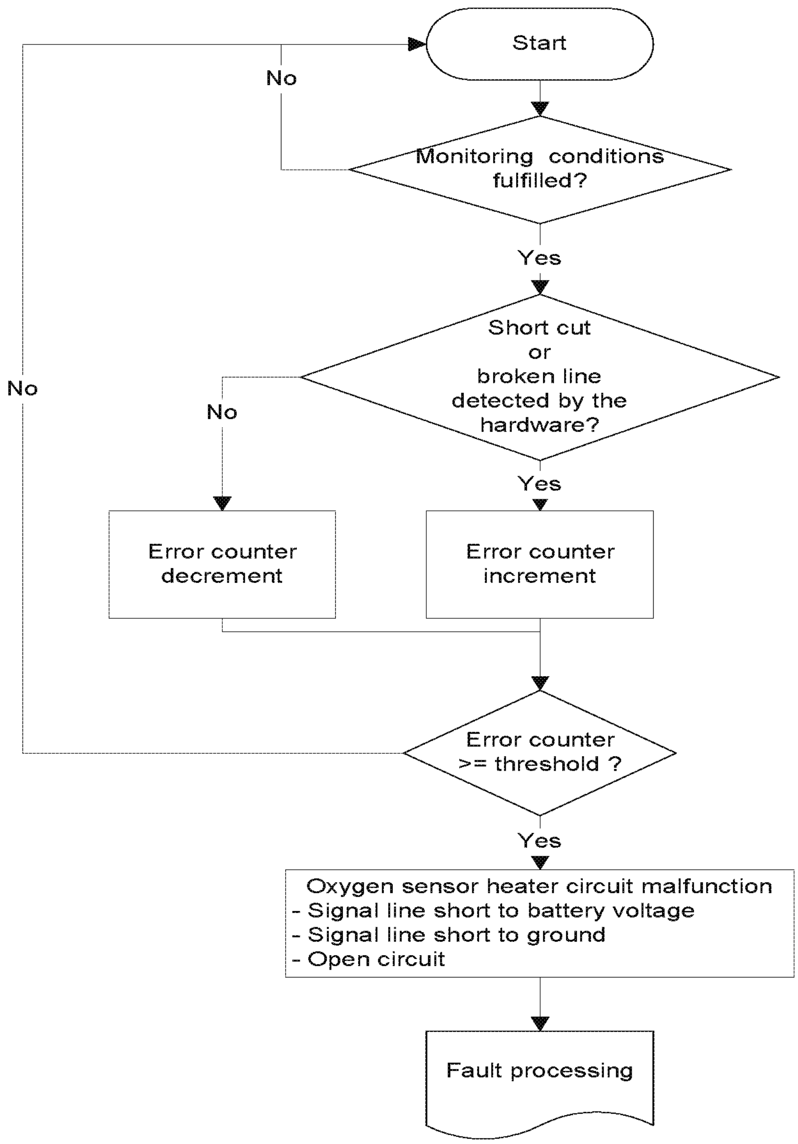
## Upstream Oxygen Sensor Heater Circuit Monitor

For proper function of the oxygen sensor, the sensor element must be heated. A non functioning heater delays the sensor readiness for closed loop control and thus influences emissions. The signal for the O2 sensor heater is pulse-width modulated. The oxygen sensor heater circuit monitor detects the following malfunctions by evaluating the error information received from the heater power driver in the ECM: heater short circuit to battery, short circuit to ground, and open circuit.

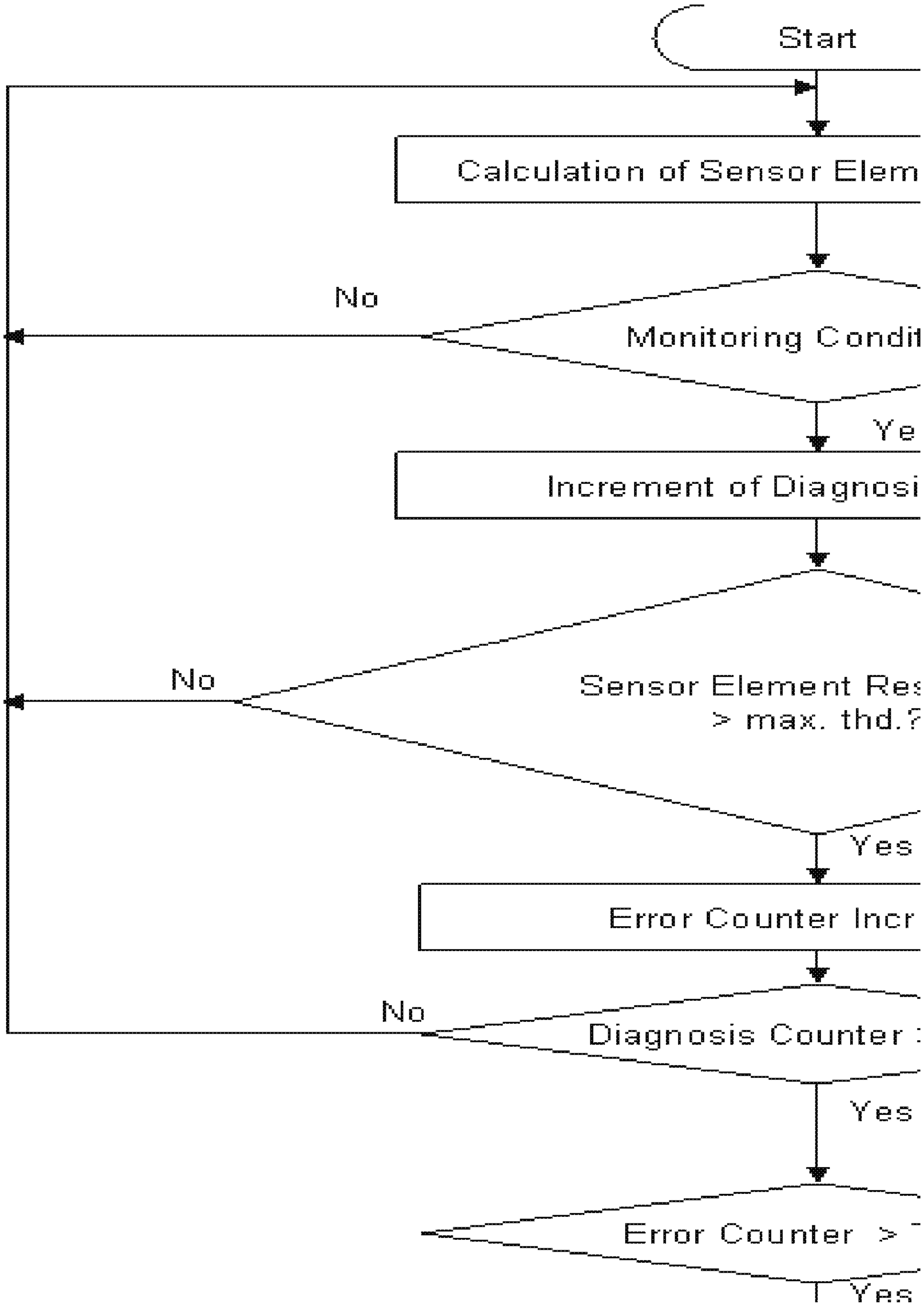
### Heater Performance

This monitor determines the rationality of the upstream(or downstream) O2 sensor heater fault if the measured upstream (or downstream) O2 sensor resistance is lower than the predetermined threshold after a number of monitoring cycles have been carried out. Note: If the rationality test stores an error (P0053) then an additional P-code is stored automatically (P016A).

**Upstream HO2S11 Heater Electrical Checks**



## Upstream HO2S11 Heater Rationality



| HO2S Heater Monitor Operation: | |
|---|---|
| DTCs Sensor 1 | P0030 O2 Heater Control Circuit, Bank 1, Sensor 1<br>P0031 O2 Heater Control Circuit Low, Bank 1, Sensor 1<br>P0032 O2 Heater Control Circuit High, Bank 1, Sensor 1<br>P0053 O2 Heater Resistance, Bank 1, Sensor 1 |
| Monitor execution | once per driving cycle for heater current, continuous for voltage monitoring |
| Monitor Sequence | None |
| Sensors OK | HO2S, HO2S heater, MAF |
| Monitoring Duration | 400 ms for heater voltage check, 20 sec for heater current check |

| Typical HO2S heater monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Battery voltage | 11 V | 16 V |
| O2 heater pulsewidth (P0032) | 5.07 % | 99.6 % |
| Modeled Exhaust gas temp at upstream sensor (P0032 only) | 200 °C | |
| Modeled Exhaust gas temp at upstream sensor (P0053 only) | | 699 °C |
| O2 heater pulsewidth (P0053 only) | 1.18 % | 99.6 % |
| Minimum required cooling energy at upstream position (P0053 only) | 10000 J | |
| MAF (P0053 only) | 25 kg/h | 65 kg/h |
| O2 heater on time (P0053 only) | 30 s | |

**Typical HO2S heater check malfunction thresholds:**

P0030

Open circuit determined by heater driver

P0031

Short to ground determined by heater driver

P0032

Short to battery determined by heater driver

P0053

Heater resistance: ≥ 500 ohms for 15 of 20 test samples

| J1979 HO2S Heater Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | Units |
| $41 | $C1 | HO2S11 Heater Resistance | Ohms |
| $42 | $C2 | HO2S21 Heater Resistance | Ohms |

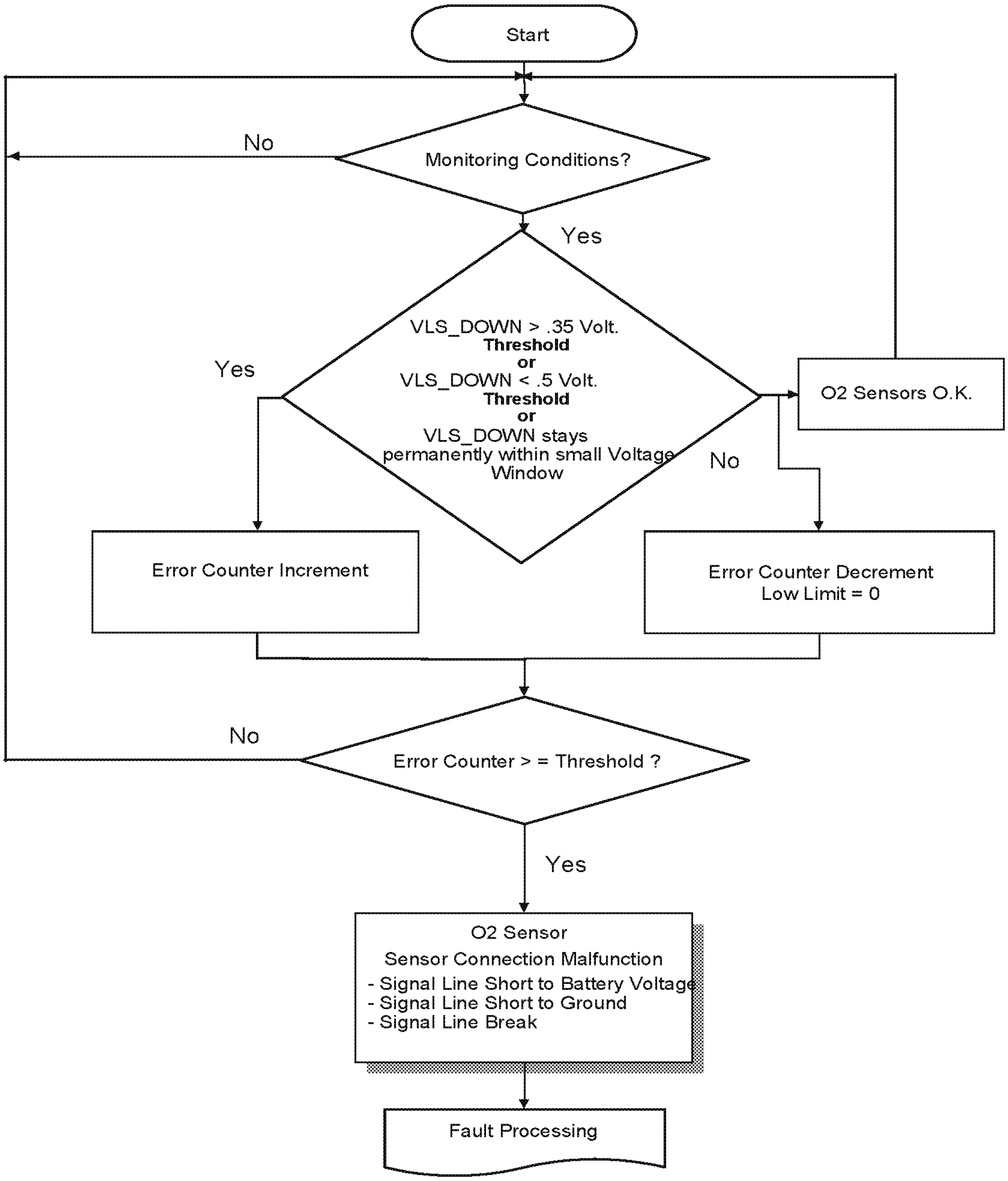
## Downstream Oxygen Sensor Monitoring

The downstream oxygen sensor circuit monitor detects the HO2S sensor voltage is above or below a calibratable threshold or if it is not active, stuck at some voltage.

The downstream oxygen sensor monitor detects if the HO2S signal circuit voltage is shorted to ground (low signal), signal circuit voltage is high (high signal), or an open circuit causing the signal circuit voltage to be inactive or stuck at some voltage.

Sensor signal plausibility and signal activity monitoring is performed during coasting conditions during fuel cut-off (Slow Response). A malfunction is also detected, if the sensor signal is permanently above the minimum threshold.

Downstream HO2S Circuit Check



| HO2S12 circuit check operation: | |
|---|---|
| DTCs | P0136 – HO2 circuit (Bank 1, Sensor 2).<br>P0137 – HO2 circuit low voltage (Bank 1, Sensor 2).<br>P0138 – HO2 circuit high voltage (Bank 1, Sensor 2).<br>P2A01 – O2 Sensor Circuit Range/Performance (Bank 1 Sensor 2). |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | HO2S, HO2 heater, MAF |
| Monitoring Duration | 12.7, 25.5 or 105 seconds to register a malfunction |

| Typical HO2S12 DFSO check entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Stuck above lean voltage limit (P0136 only) | 0.35 volts | |
| Stuck below rich voltage limit (P0136 only) | | 0.5 volts |
| Time stuck (P0136 only) | 5 seconds | |
| Exhaust gas temp (P0136 only) | 350 °C | |
| Time since entry conditions meet (P0136 only) | 100 sec | |
| Mass Air Flow (P0137 only) | 12 kg/hr | |
| Time stuck at low voltage (P0137 only) | 25.5 sec | |
| Time stuck at high voltage (P0132 only) | 12.7 seconds | |
| Oxygen sensor voltage for activation of DFCO test (P2A01 only) | 0.601 V | |
| Integrated Mass Air Flow to start DFCO monitor (P2A01 only) | 500 g | |
| Integrated Mass Air Flow to enter DFCO monitor (P2A01 only) | 20 g | |
| Integrated Mass Air Flow to exit DFCO monitor (P2A01 only) | | 150 g |
| Integrated Mass Air Flow during DFCO monitor > Integrated Mass Air Flow from previous DFCO monitor (P2A01 only) | | |

| Typical HO2S12 circuit check malfunction thresholds: |
| --- |
| <u>P0136</u> |
| O2 sensor internal resistance: ≥ 50000 ohms, voltage stuck between 0.35 and 0.5 volts |
| <u>P0137</u> |
| O2 sensor resistance < 2 ohms and O2 sensor voltage stuck at < .009 volts |
| <u>P0138</u> |
| O2 sensor voltage stuck above 1.1volts |
| <u>P2A01</u> |
| O2 sensor voltage stuck > 0.3 V during DFCO |

## Downstream Oxygen Sensor Slow Response Monitor

This non intrusive diagnosis can detect the sluggish behavior of the rich/lean switch times during the transition to decel fuel cut-off. The malfunction thresholds are a function of MAF and signal band limits.

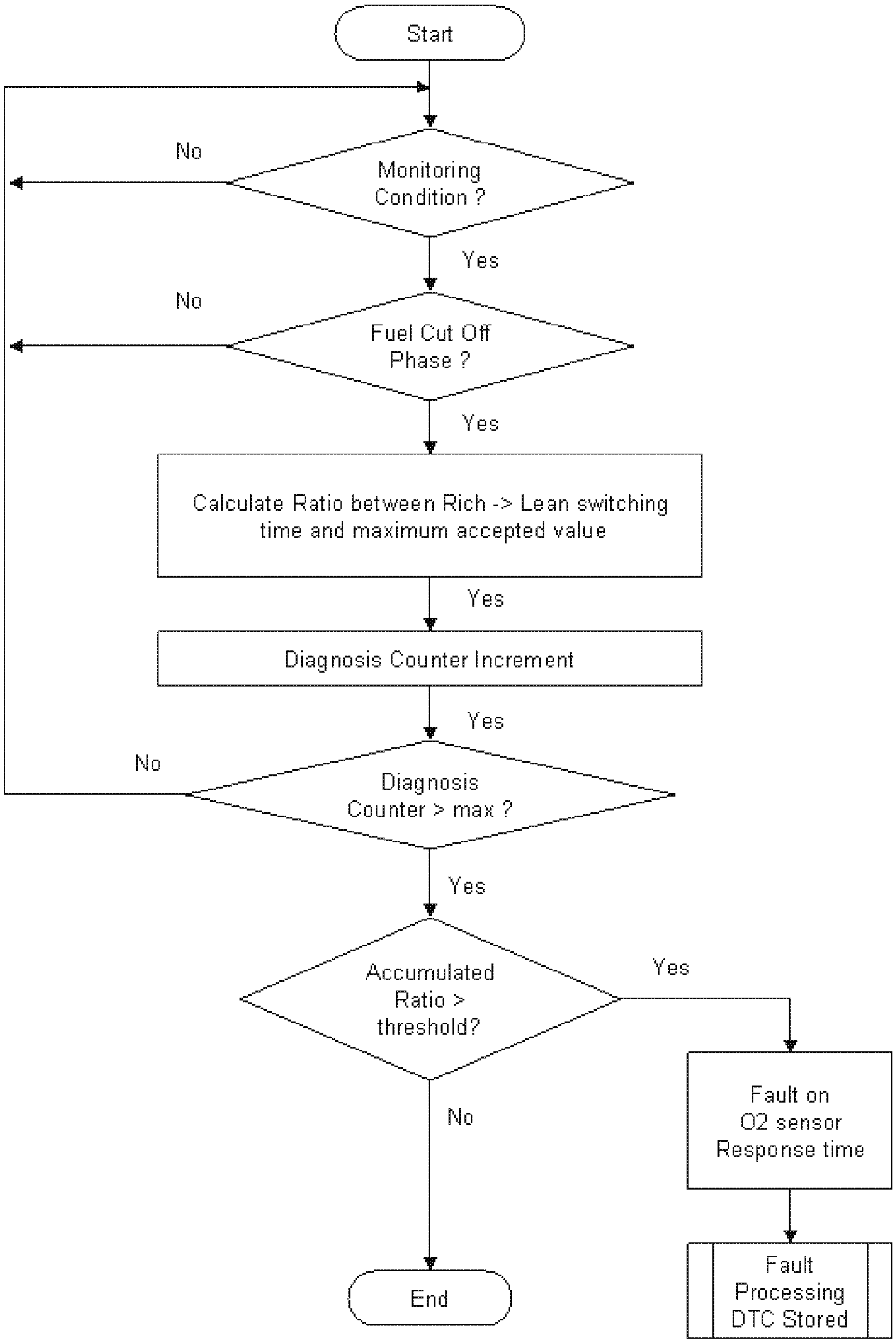
Monitoring function:

After the enable conditions are met and DFCO is determined to be active, the current downstream O2 voltage is monitored and stored. If the stored value is above a calibratable threshold, and MAF is within a calibratable window, the test is started.

Once the sensor voltage drops a calibratable percentage of the stored value, a timer is started. This timer is then stopped when the voltage drops a calibratable percentage of that stored value. At this point the test is determined to be valid and the diagnostic counter is incremented by one.

The switching time value is then converted to a weighted value. This process is repeated for a calibratable number of DFCO events. Each time the diagnostic counter is incremented the weighted value is added to a total value. At the end of the maximum number of DFCO events, the total value is divided by the number of DFCO events and another value is developed. This value is then compared to a threshold. If the value exceeds the threshold the sensor is determine to be slow and the corresponding fault code is stored.

# Downstream Oxygen Sensor - Signal Switching check



| Downstream HO2S12 Response Rate Operation: | |
|---|---|
| DTCs | P013A HO2S12 (Slow response - Rich to Lean) |
| Monitor execution | Once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | HO2S, HO2S heater, MAF, VS, ECT |
| Monitoring Duration | 3 DFCO events > 1 second long |

| Typical Downstream HO2S12 response rate entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Closed Loop Fuel Control | Yes | |
| Engine Coolant Temperature | 60 °C | |
| Catalyst temperature | 348 °C | |
| Vehicle speed | 12 mph | 77 mph |
| DFCO active | | |
| Down stream O2 sensor Voltage at start of DFCO | 0.5 V | |
| Maximum Increase of O2 Voltage during DFCO test | | < 0.029 V |
| Mass Air Flow during DFCO | 6 kg/h | 110 kg/h |
| Internal resistance of downstream oxygen sensor | | 5000 ohms |
| MAF integral out of DFCO | 10 g | 1000 g |
| Catalyst temperature | 300 °C | 1000 °C |

**Typical Downstream HO2S12 response rate malfunction thresholds:**

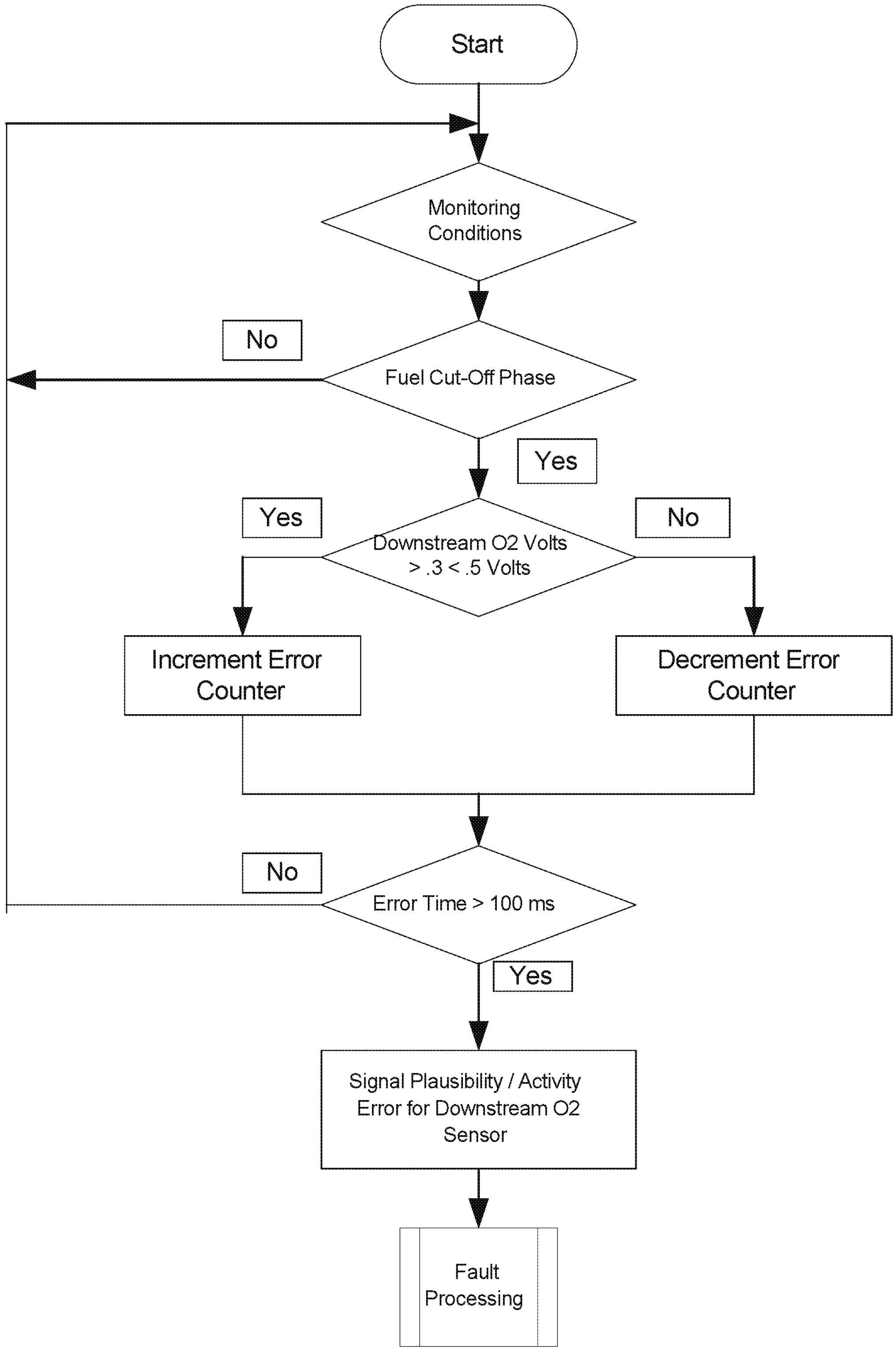
P013A

Slow Response (Average ratio for the rich to lean switching time determination): ≤ 0.1

Slow Response (Diagnostic window based on O2 voltage at start of DFCO): > 15 % and < 70 %

| J1979 Downstream HO2S12 response rate Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | |
| $02 | $84 | Monitoring downstream sensor signal during throttle cut off | Volts |
| $02 | $8A | Rich to lean switching time ratio | None |

## Downstream O2 Sensor Functional Check



| Downstream HO2S12 Functional Check Operation: | |
|---|---|
| DTCs Sensor 2 | P0140 HO2S12 No activity<br>P2270 HO2S12 Signal Stuck Lean<br>P2271 HO2S12 Signal Stuck Rich |
| Monitor execution | once per driving cycle for activity test |
| Monitor Sequence | None |
| Sensors OK | CKP, CMP, VVT, MAF, HO2S, HO2S heater, misfire, CPS, TPS, ECT, Fuel monitor |
| Monitoring Duration | continuous until monitor completed |

| Typical Downstream HO2S12 functional check entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Lambda set point for lean fault detection | 0.80 | |
| Integrated mass air flow outside of DFCO | | 400 g |
| Integrated mass air flow needed for open loop test to ensure the desired lambda at downstream sensor | | 50 g |
| Integrated mass air flow in DFCO | 10 g | |
| Time after start | 120 s | |

| Typical Downstream HO2S12 functional check malfunction thresholds: |
|---|
| P0140<br>No activity, O2 sensor voltage stuck between 0.298 V and 0.550 V<br>P2270<br>Rich voltage could not be achieved, O2 sensor stuck lean: < 0.249 V<br>P2271<br>Lean voltage could not be achieved, O2 sensor stuck rich:> 0.555 V |

## Downstream Oxygen Sensor Heater Circuit Monitor

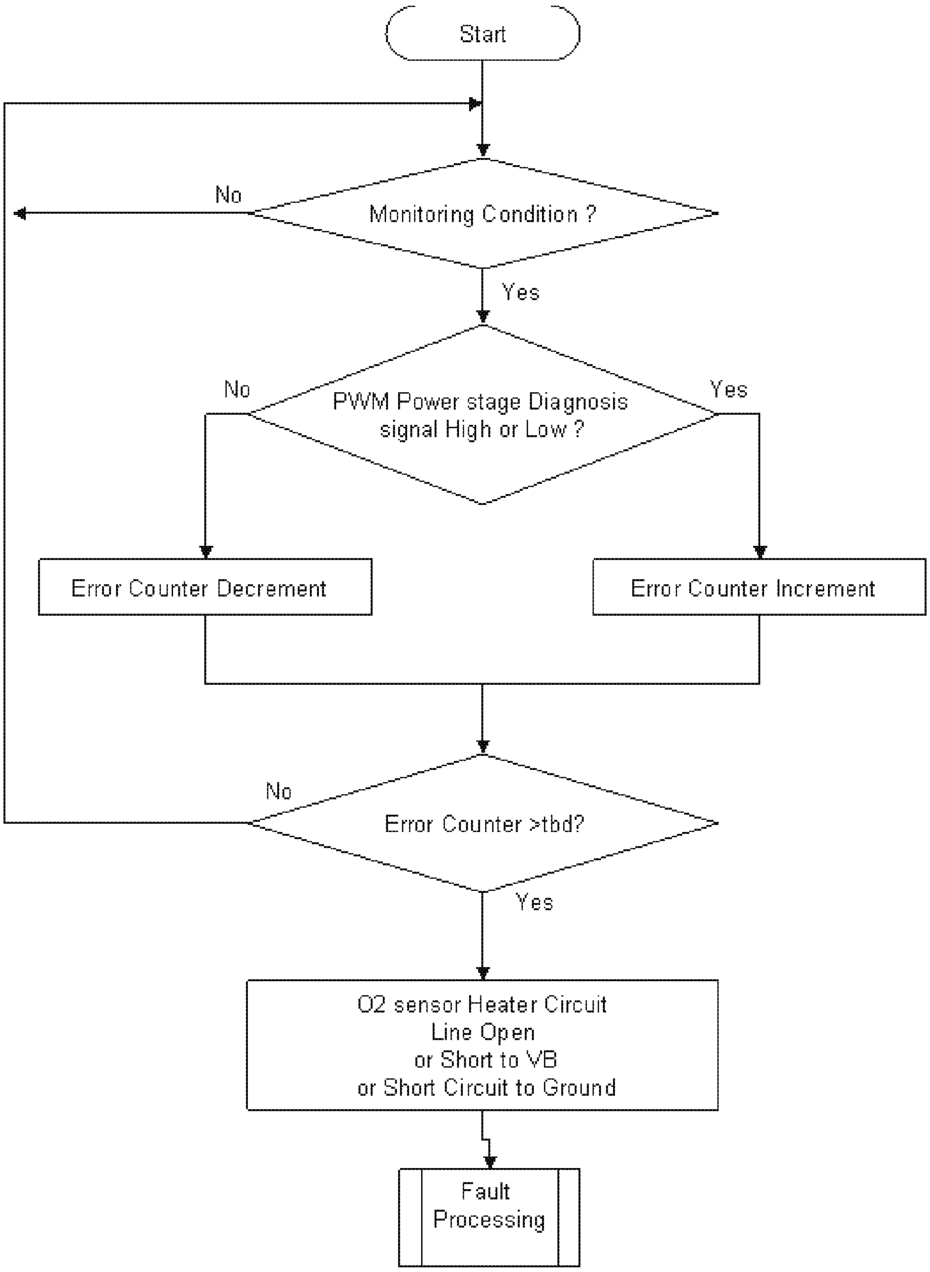
For proper function of the oxygen sensor, the sensor element must be heated. A non functioning heater delays the sensor readiness for closed loop control and thus influences emissions. The signal for the O2 sensor heater is pulse-width modulated. The oxygen sensor heater circuit monitor detects the following malfunctions by evaluating the error information received from the heater power driver in the ECM: heater short circuit to battery, short circuit to ground, and open circuit.

**Heater Performance**

The monitoring strategy is based on the comparison of the O2 sensor heater resistance to an absolute threshold during deceleration conditions where the exhaust temperature is sufficiently low as to cause the sensor ceramic temperature to fall outside normal operating levels in cases where the heating power is insufficient.

The cooling energy of the exhaust gas is calculated and compared to a calibrated threshold. The heater monitor is active if the calculated energy is equal or exceeds the threshold. Then the O2 sensor heater is compared to a calibrated threshold. If the heater resistance is equal or exceeds the threshold, an O2 sensor heater malfunction is detected.

**Downstream HO2S Heater Electrical Checks**



| HO2S12 Heater Monitor Operation: | |
|---|---|
| DTCs Sensor 1 | P0036 O2 Heater Control Circuit, Bank 1, Sensor 2<br>P0037 O2 Heater Control Circuit Low, Bank 1, Sensor 2<br>P0038 O2 Heater Control Circuit High, Bank 1, Sensor 2<br>P0054 O2 Heater Resistance, Bank 1, Sensor 2 |
| Monitor execution | once per driving cycle for heater current, continuous for voltage monitoring |
| Monitor Sequence | None |
| Sensors OK | HO2S, HO2S heater, MAF |
| Monitoring Duration | 400 ms for heater voltage check, 20 sec for heater current check |

| Typical HO2S12 heater monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Battery voltage | 11 V | 16 V |
| O2 heater pulsewidth (P0038) | 5.07 % | 99.6 % |
| Modeled Exhaust gas temp at downstream sensor (P0038 only) | 349 °C | |
| O2 heater pulsewidth (P0054 only) | 1.18 % | 99.6 % |
| Modeled Exhaust gas temp at downstream sensor (P0054 only) | | 750 °C |
| Minimum required cooling energy at upstream position (P0054 only) | 10000 J | |
| MAF (P0054 only) | 25 kg/h | 65 kg/h |
| O2 heater on time (P0054 only) | 180 s | |

| Typical HO2S12 heater check malfunction thresholds: |
|---|
| P0036<br>Open circuit determined by heater driver<br>P0037<br>Short to ground determined by heater driver<br>P0038<br>Short to battery determined by heater driver<br>P0054<br>Heater resistance: ≥ 300 ohms for 15 of 20 test samples |

| J1979 HO2S Heater Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | Units |
| $41 | $C1 | HO2S11 Heater Resistance | Ohms |
| $42 | $C2 | HO2S21 Heater Resistance | Ohms |

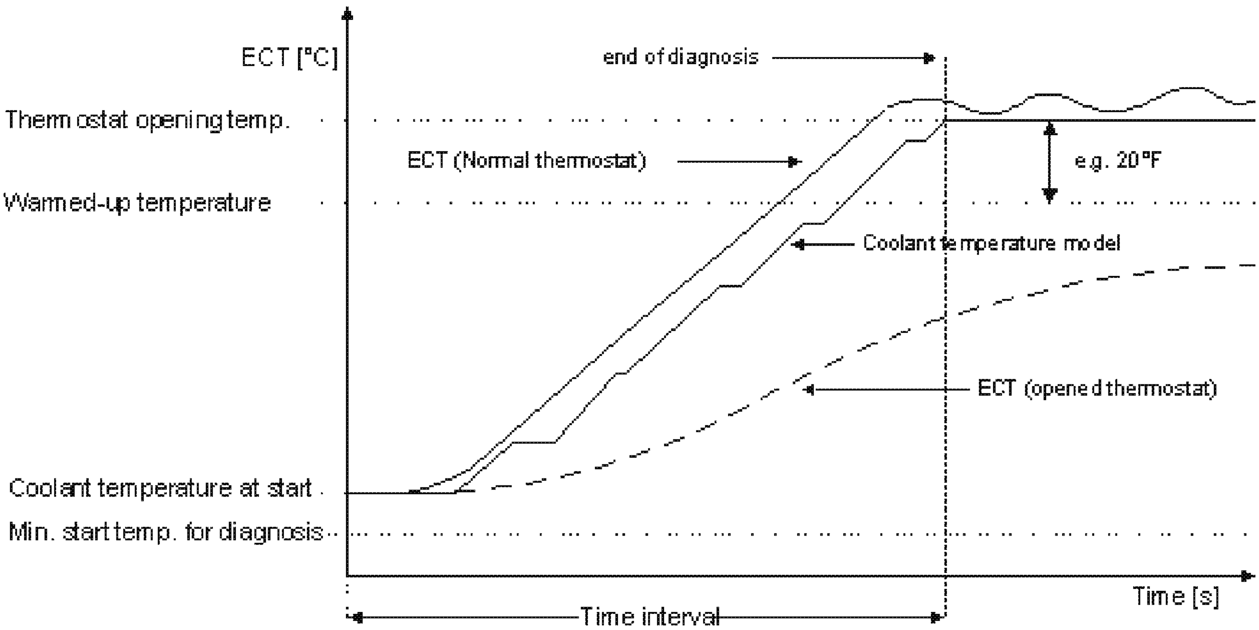
## Thermostat Monitor

The coolant thermostat monitor is designed to detect a thermostat that is slow to open or is stuck open. It is based on the comparison of the measured Engine Coolant Temperature (ECT) sensor signal and the calculated ECT model. The ECT model calculation is depending on engine load/speed and the intake air temperature.

A malfunctioning coolant thermostat is detected if the calculated ECT model has exceeded the thermostat opening temperature and the measured ECT sensor signal remains below a threshold (the highest diagnostic enable temperature).

To prevent false DTCs, conditions for low load, long deceleration duration and Intake Air Temperature (IAT) during the monitoring period are checked. If the monitoring conditions are met, the thermostat DTC is set; otherwise the thermostat monitor is suspended for the current driving cycle.

Thermostat Monitor Method:

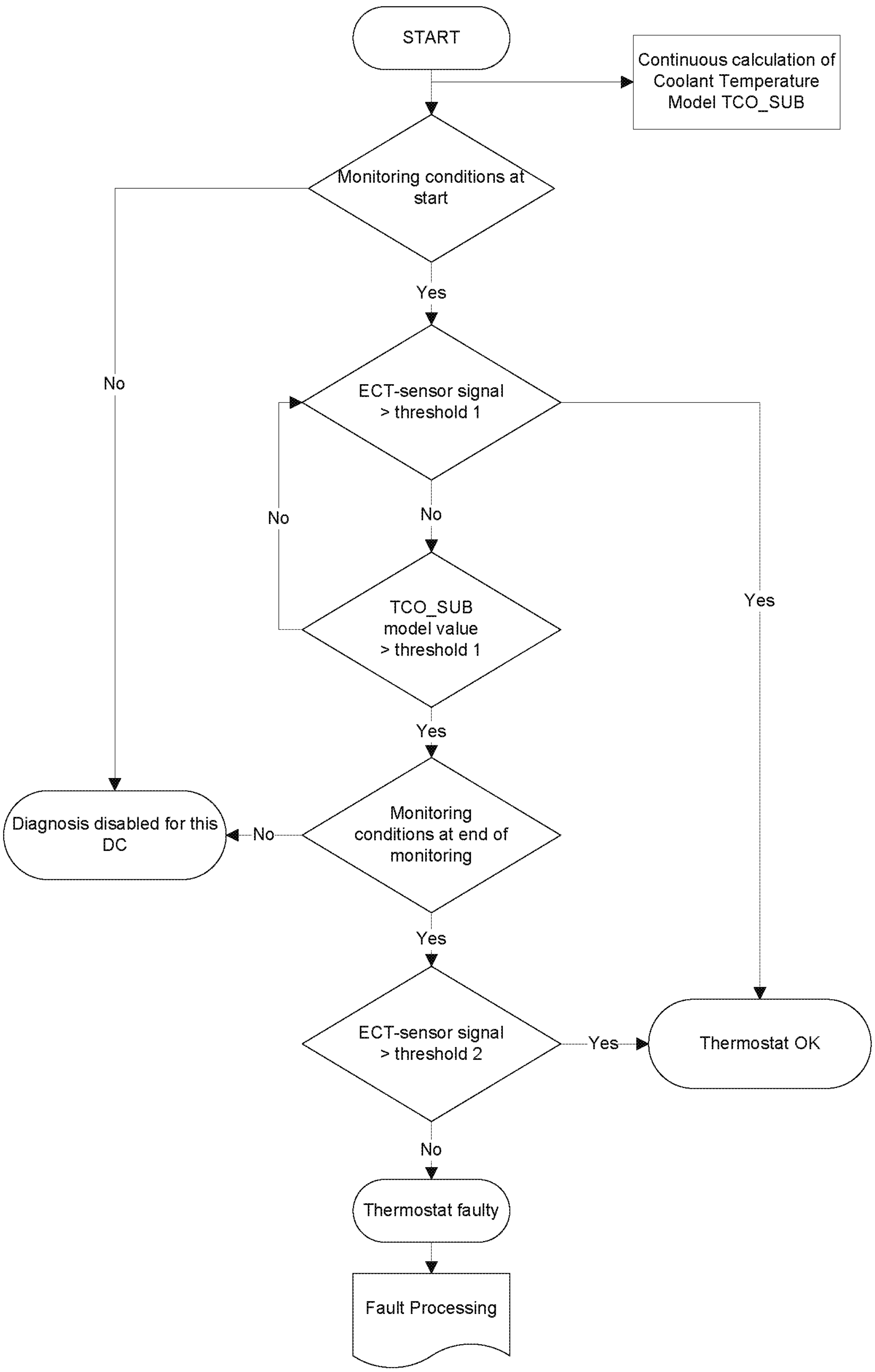



A comparison between the measured coolant temperature and the "warmed-up temperature" is done after a specific time interval. The interval itself is based on the coolant temperature model.

As soon as the model temperature exceeds the thermostat opening temperature and all other monitoring conditions are fulfilled at the same time, a valid diagnosis occurs.

At that time, if the measured coolant temperature is higher than warmed-up temperature, the thermostat is considered to be a normal thermostat. If the measured coolant temperature is lower than warmed-up temperature, the thermostat is considered to be stuck open.

# Thermostat Monitoring



| ECT Below Thermostat Regulating Temperature | |
|---|---|
| DTCs | P0128 |
| Monitor execution | Once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | ECT, MAF, VS, CKP, TPS, IAT |
| Monitoring Duration | 127 seconds, based on Inlet Air temperature |

| Typical ECT Below Thermostat Regulating Temperature check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Percentage of Time at Vehicle speed > than 20 mph | 60.15 % | |
| Percentage of time at MAF > 18 … 20 kg/h | 36% | |
| Percentage of time in DFCO | | 10% |
| Percentage of Time at Vehicle speed > than 47 mph | | 36% |
| Difference between IAT and ECT | | -20.25 °C |

| Typical ECT Below Thermostat Regulating Temperature check malfunction thresholds: |
|---|
| Measure ECT > 72.75 °C after modeled ECT exceeds 81.75 °C |

## Cold Start Emission Reduction Component Monitor

The Cold Start Emission Reduction (CSER) Component Monitor works by validating the operation of the components of the system required to achieve the cold start emission reduction strategy, namely retarded spark timing and elevated idle airflow.

### Low Idle RPM Test

When the CSER strategy is enabled, the idle air control system will request a higher idle rpm, elevating engine airflow.

| CSER low rpm test operation: | |
|---|---|
| DTCs | P050A – Cold Start Idle Air Control System Performance |
| Monitor execution | Once per driving cycle, from startup with CSER active |
| Monitor Sequence | None |
| Sensors OK | CPS, ECT, MAF, TPS |
| Monitoring Duration | 3 seconds |

| CSER typical low rpm test entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine speed | 100 rpm | |
| ECT | -10 °C | |
| Engine Run Time | 100 s | |
| Torque control at limit | 2 s | |
| Battery voltage | 11 V | 16 V |
| Mass Air Flow | 240 mg/stk | |
| Stabilization Period | 3 s | |

| CSER typical low rpm flow test malfunction thresholds: |
|---|
| RPM Lower than Commanded (Table Based on RPM & ECT & Time after start): > 100 to 150 rpm<br>RPM Higher than Commanded (able Based on RPM & ECT & Time after start): > 350 to 400 rpm |

## Spark Timing Monitor

When the CSER strategy is enabled, the idle air control system will request a retarded spark timing, increasing engine airflow.

| CSER spark timing test operation: | |
|---|---|
| DTCs | P050B – Cold Start Ignition timing Performance |
| Monitor execution | Once per driving cycle, from startup with CSSRE active |
| Monitor Sequence | None |
| Sensors OK | CPS, ECT, MAF, TPS |
| Monitoring Duration | 3 seconds |

| CSER typical spark timing test entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition angle at idle speed | | 0 deg |
| Ignition angle at part throttle | | 0 deg |
| ECT | -6.75 °C | 70 °C |
| Engine run time | 0 sec | |
| BARO | 75 kPa | |

| CSER typical spark timing test malfunction thresholds: |
|---|
| Ignition angle integral and Time in idle. (Table based on ECT & MAF) > 0.2<br>Ignition angle integral and Time in part load. (Table based on ECT & MAF) > 0.2 |

## Cold Start Variable Cam Timing Monitor

If the VCT cam phasing is used during a cold start to improved catalyst heating, the VCT system is checked functionally by monitoring the closed loop cam position error correction. If the proper cam position cannot be maintained and the system has an advance or retard error greater than the malfunction threshold, a cold start emission reduction (CSER) VCT control malfunction is indicated (P052B (Bank 1).

| CSER VCT Target Error Check Operation: | |
|---|---|
| DTCs | P052B – Cold start intake camshaft timing over-retarded (Bank 1)<br><br>P054B – Cold start exhaust camshaft timing over-retarded (Bank 1) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | VVT(P2089, P2088, P0010, P2091, P2090, P0013), system voltage (P0562, P0563), No ECU errors (P061C) |
| Monitoring Duration | 100 ms |

| Typical CSER VCT target error entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| VVT active | | |
| Battery Voltage | 10 V | |
| Engine speed | 1500 | 5000 |
| Engine Oil Temperature Model | 0 °C | 120 °C |
| Camshaft commanded position steady | | 0.75 deg crank |

| Typical CSER VCT target error malfunction thresholds: |
|---|
| Integrated difference between camshaft actual position and camshaft setpoint ≥ 100 deg crank |

## Cold Start Emission Reduction System Monitor

The Cold Start Emission Reduction System Monitor was introduced for the 2007 MY on vehicles that meet the LEV-II emission standards. It replaces the Cold Start Emission Reduction Component Monitor. The Cold Start Emission Reduction (CSER) Monitor detects the lack of catalyst warm up resulting from a failure to apply sufficient CSER during a cold start. It does this by using the inferred catalyst temperature model to determine how closely the actual catalyst temperature follows the expected catalyst temperature during a cold start. How closely the actual temperature follows the expected temperature is reflected in a ratio which is compared with a calibratable threshold.

### Temperatures Used

The actual catalyst temperature is the same inferred catalyst temperature that is used by other portions of the engine control system, including the CSER control system. The inputs to this actual temperature are measured engine speed, measured air mass, and commanded spark.

The expected catalyst temperature is calculated using the same algorithm as the actual catalyst temperature, but the inputs are different. Desired engine speed replaces measured engine speed, desired air mass replaces measured air mass, and desired cold start spark replaces commanded spark. The resulting temperature represents the catalyst temperature that is expected if CSER is functioning properly.

### Ratio Calculation

A ratio is calculated to reflect how closely the actual temperature has followed the expected temperature. This ratio is the difference between the two temperatures at a certain time-since-start divided by the increase in expected temperature over the same time period. The ratio, then, provides a measure of how much loss of catalyst heating occurred over that time period.

This ratio correlates to tailpipe emissions. Therefore applying a threshold to it allows illumination of the MIL at the appropriate emissions level. The threshold is a function of ECT at engine start.

### General CSER Monitor Operation

During the first 15 seconds of a cold start, the monitor checks the entry conditions, counts time in idle, and observes catalyst temperature.

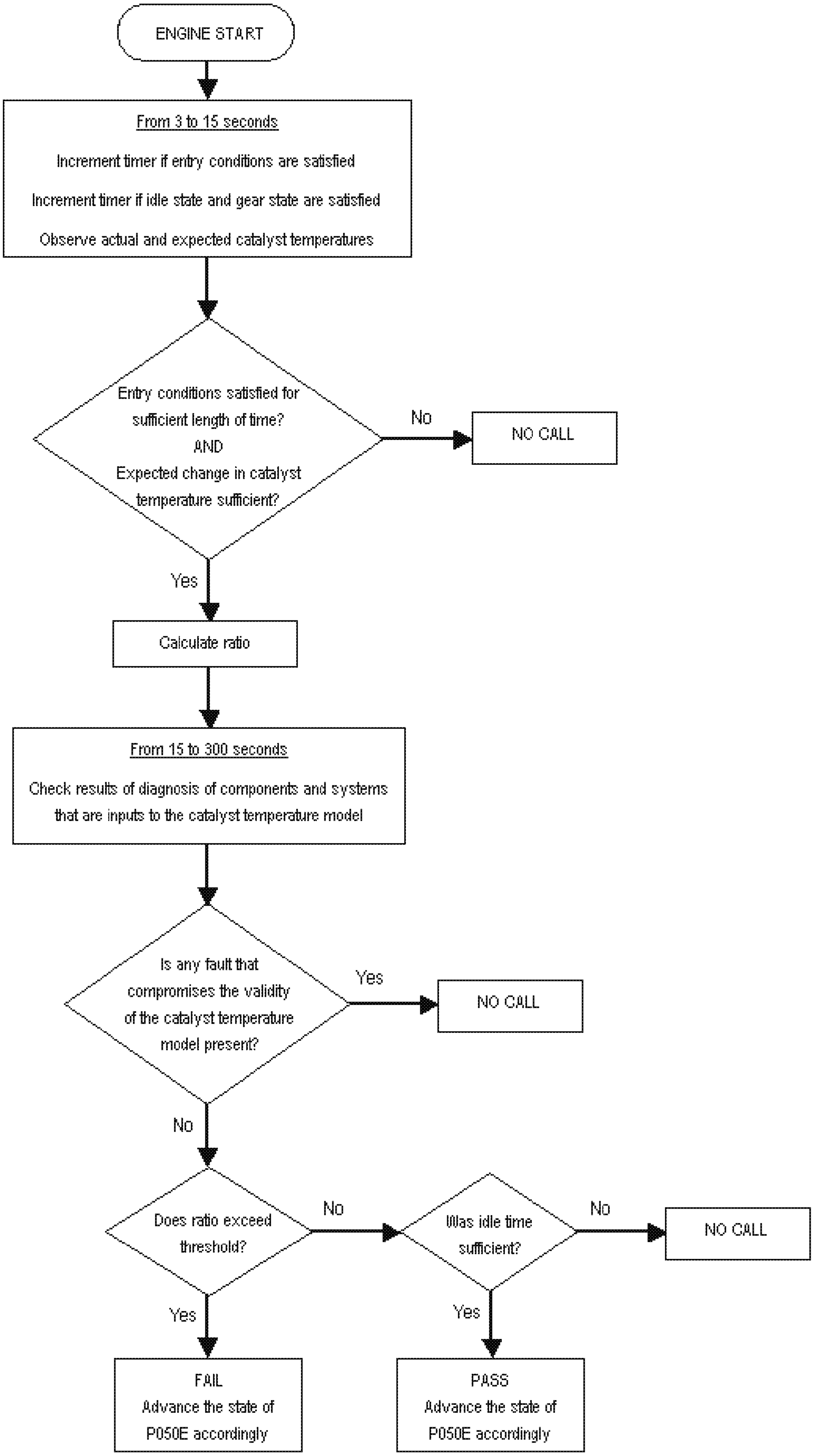
If the expected change in catalyst temperature is large enough, the monitor calculates the ratio as described above. Otherwise the monitor does not make a call.

The monitor then begins the waiting period, which lasts from the time the ratio is calculated (15 seconds after engine start) until 300 seconds after engine start. This 5-minute wait allows time to diagnose other components and systems that affect the validity of the catalyst temperature model. During this waiting period, there are no constraints on drive cycle and the monitor cannot be disabled without turning off the key.

At the end of the waiting period, if no other faults that could compromise the validity the catalyst temperature model are found, the monitor compares the ratio to the threshold.

If the ratio exceeds the threshold, the monitor considers the test a fail, and the monitor is complete.

If the ratio falls below the threshold, the monitor determines whether the idle time was sufficient. If so, it considers the test a pass and the monitor is complete. If idle time was not sufficient, the monitor does not make a call and does not complete. This prevents tip-ins from resulting in false passes.



ENGINE START
From 3 to 15 seconds
Increment timer if entry conditions are satisfied
Increment timer if idle state and gear state are satisfied
Observe actual and expected catalyst temperatures
Entry conditions satisfied for sufficient length of time?
AND
Expected change in catalyst temperature sufficient?
No
NO CALL
Yes
Calculate ratio
From 15 to 300 seconds
Check results of diagnosis of components and systems that are inputs to the catalyst temperature model
Is any fault that compromises the validity of the catalyst temperature model present?
Yes
NO CALL
No
Does ratio exceed threshold?
No
Was idle time sufficient?
No
NO CALL
Yes
Yes
FAIL
Advance the state of P050E accordingly
PASS
Advance the state of P050E accordingly

| CSER Monitor Operation | |
|---|---|
| DTC | P050E: Cold Start Engine Exhaust Temperature Out Of Range |
| Monitor Execution | Once per driving cycle, during a cold start |
| Monitor Sequence | Monitor data collection takes place during first 15 seconds of cold start as long as there are no active DTCs |
| Sensors OK | MAF, TPS, misfire, injectors, Fuel monitor, CKP, ignition coils, IAT, ECT, VVT |
| Monitoring Duration | Monitor completes in 100 ms after conditions are meant |

| **Typical CSER VCT target error entry conditions:** | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine run time | 3 s | |
| Battery voltage | 11 V | 16 V |
| ECT @ start | 1.6 °C | 38 °C |
| Catalyst temp @ start | 1.6 °C | 52 °C |
| BARO | 75 kPa | |
| Fuel level | 5% | |
| Expected change in Cat Temp | 20 °C | |
| Injectors “ON”, DFCO not active | | |

| **Typical CSER Monitor malfunction thresholds:** |
|---|
| Ratio reflecting lack of observed catalyst temperature increase compared with expected catalyst temperature increase (Table Based on ECT at engine start): > 0.5 |

## Variable Valve Timing System Monitor

Variable Valve / Cam Timing (VVT/VCT) enables rotation of the camshaft(s) relative to the crankshaft (phase-shifting) as a function of engine operating conditions. With Dual Equal VCT, both intake and exhaust camshafts are retarded from the default, fully advanced position to increase EGR residual and improve fuel economy by reducing intake vacuum pumping losses. The residual charge for NOx control is obtained by backflow through the late-closing exhaust valve as the piston begins its intake stroke.

The VCT system hardware consists of a control solenoid and a pulse ring on the camshaft. The ECM calculates relative cam position using the CMP input to process variable reluctance sensor pulses coming from the pulse ring mounted on the camshaft. Each pulse wheel has N + 1 teeth where N = the number of cylinders per bank.

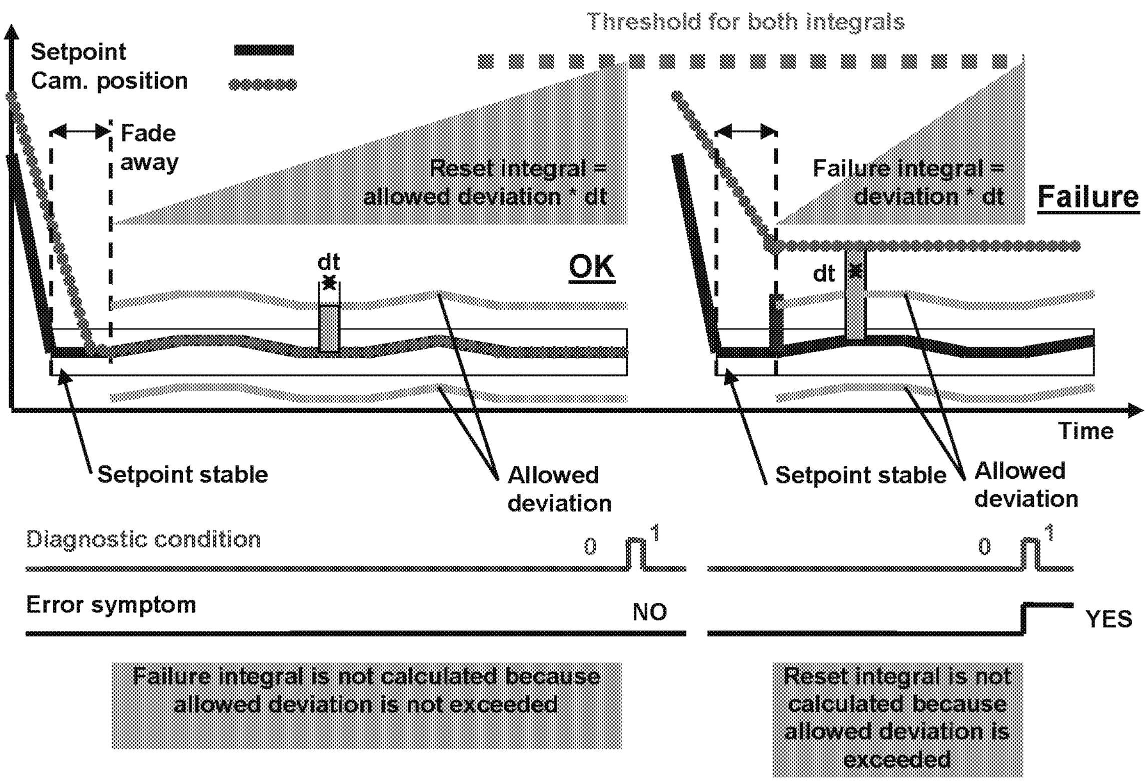
The ECM continually calculates a cam position error value based on the difference between the desired and actual position and uses this information to calculate a commanded duty cycle for the VVCT solenoid valve. When energized, engine oil is allowed to flow to the VCT unit thereby advancing and retarding cam timing.

### Variable Cam Timing Target Error

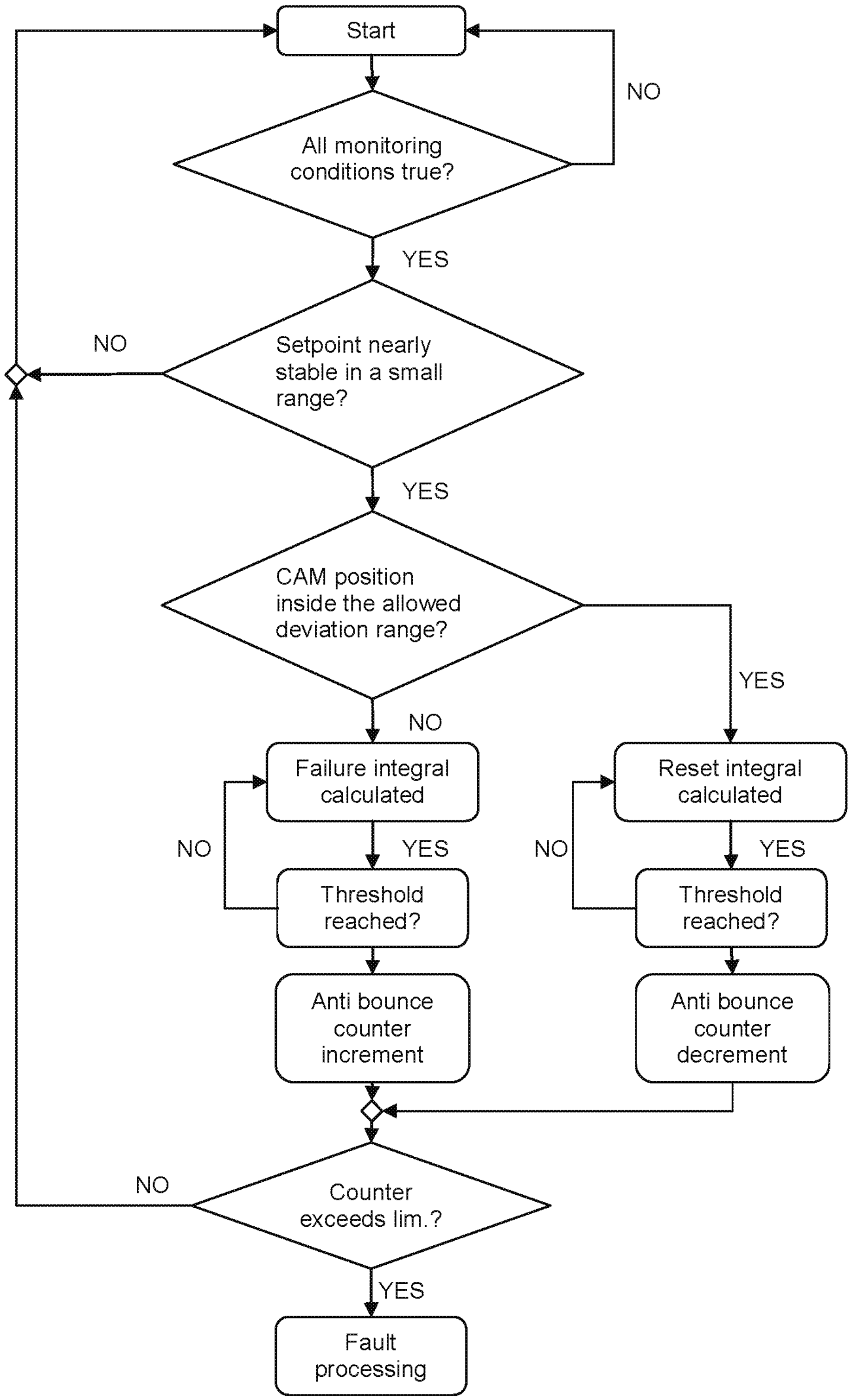
The difference between the actual cam position and the target cam position is checked. The target position has to be in a limited stable range for a certain time. If the actual position is near the target (calibratable range) the diagnosis is ok, otherwise not. This will be checked by calculating two integrals (reset integral and failure integral). Both integral values have the same thresholds

If the failure integral reaches this threshold at first, an anti-bounce counter is started; otherwise the counter will be decremented. If the counter exceeds an adjustable limit, the appropriate DTC will be stored.

**Example: Target Error**



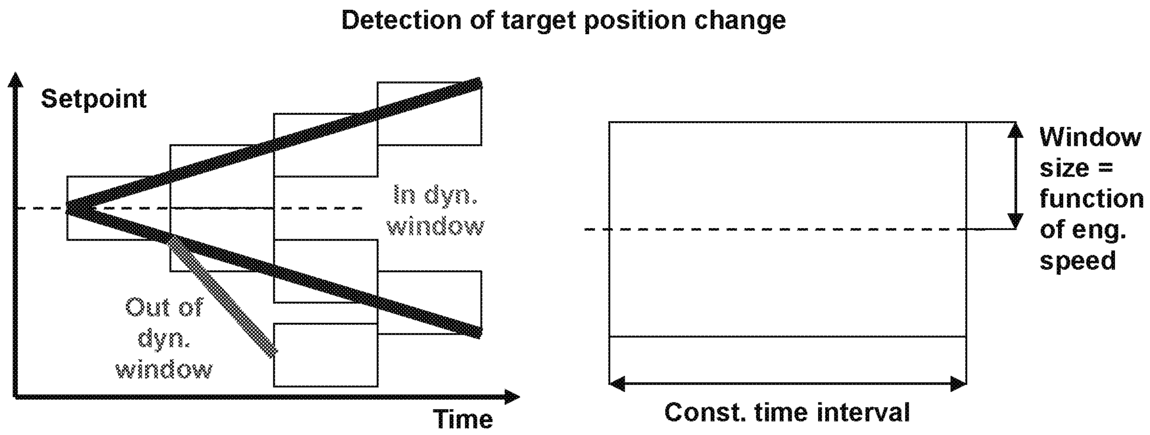
Variable Camshaft Timing Target Error



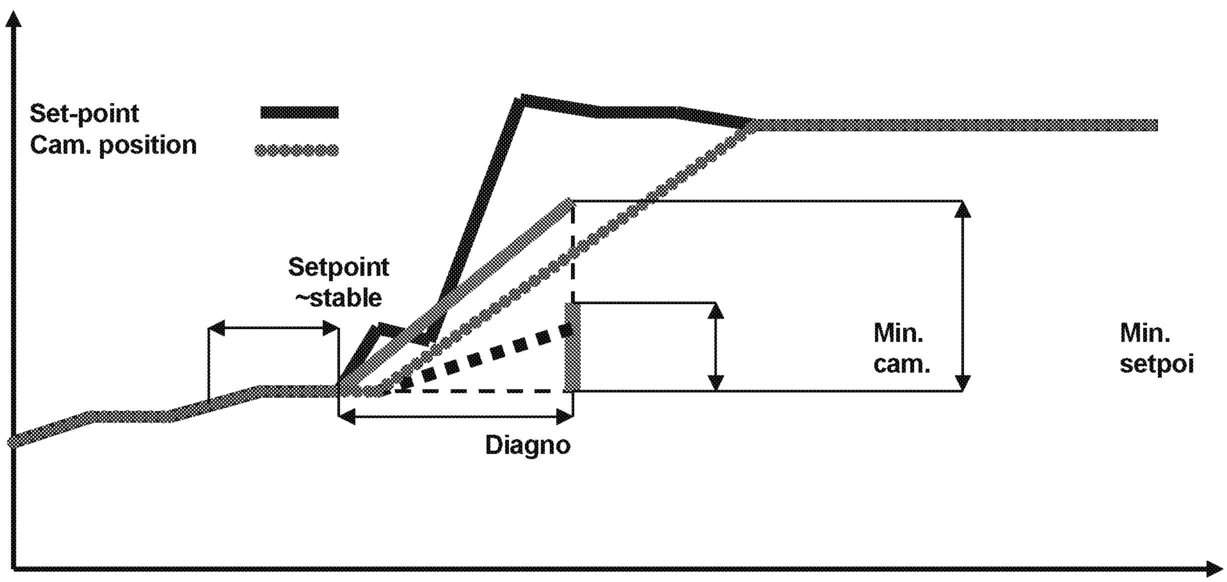
## Variable Cam Timing Slow Response

The response of the actual position on a target position change, which has to be big and quick enough, is evaluated. The set point and camshaft position are saved at the beginning of a set point change. If this change over a time is big enough (gradient), the camshaft phasing change is evaluated. If the change after the diagnostic time is smaller than a threshold, a slow response is detected, and if the value is greater, then there is no malfunction. By detecting a malfunction, an anti-bounce counter is incremented otherwise the counter will be decremented. If the counter exceeds an adjustable limit, the appropriate DTC will be stored.

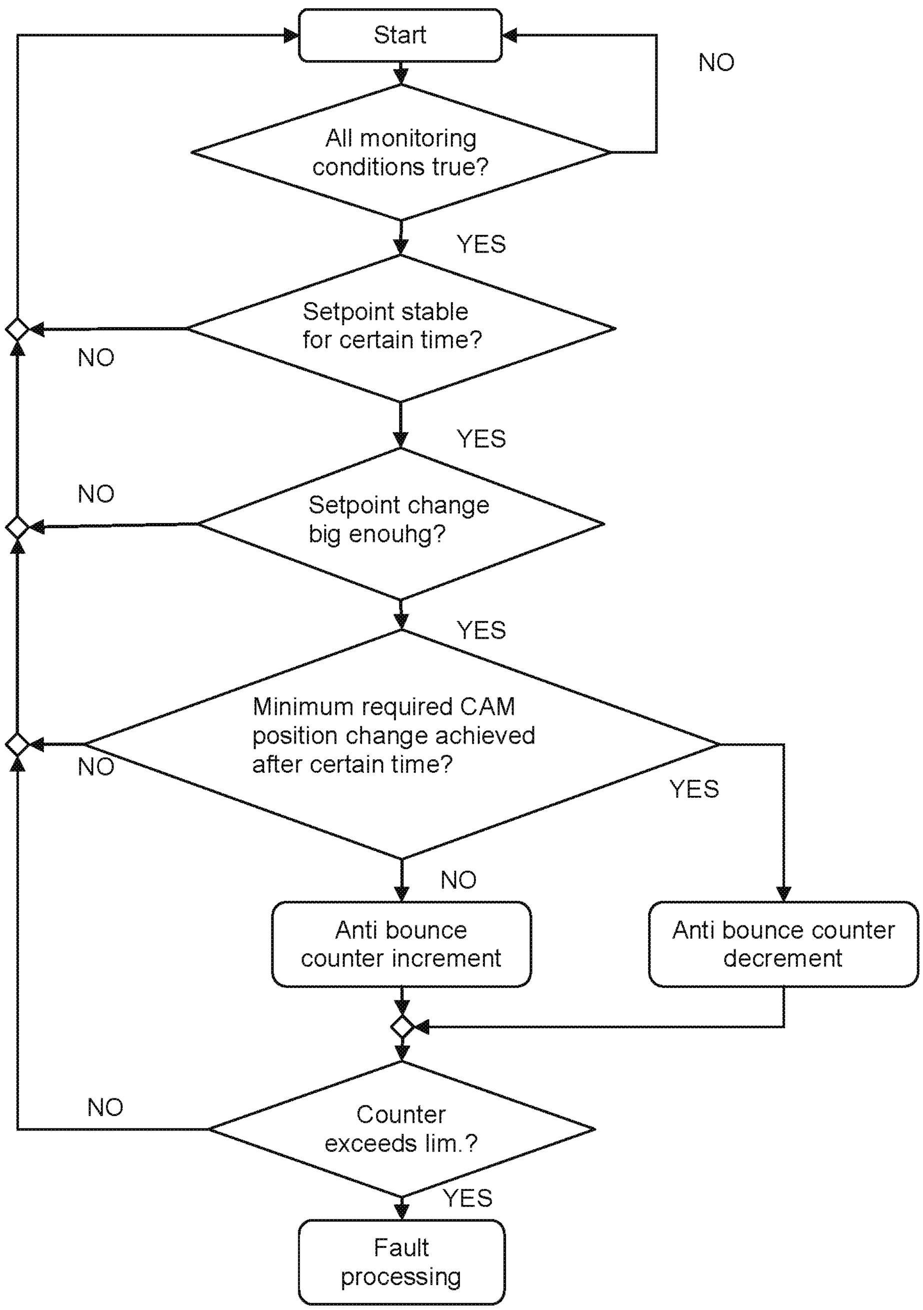
**Example 1:**




**Example 2:**



**Variable Cam Timing Slow Response**



| VVT Target Error/Slow Response Monitor Operation: | |
|---|---|
| DTCs | P000A – Intake Cam Position Actuator Slow Response<br>P0011 – Intake Cam Position Actuator Target Error<br>P0010 – Intake Camshaft Position Actuator Circuit<br>P000B – Exhaust Cam Position Actuator Slow Response<br>P0014 – Exhaust Cam Position Actuator Target Error<br>P0013 – Exhaust Camshaft Position Actuator Circuit<br>P2088 – Intake Cam Position Actuator Circuit Low<br>P2089 – Intake Cam Position Actuator Circuit High<br>P2090 – Exhaust Cam Position Actuator Circuit Low<br>P2091 – Exhaust Cam Position Actuator Circuit High |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | VVT, system voltage, internal control module engine rpm performance |
| Monitoring Duration | 3 sec for circuit faults, 1 second for target error/slow response |

| Typical VVT Target Error/Slow Response monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| VVT active | | |
| Battery Voltage | 10 V | |
| Engine speed | 1500 rpm | 5000 rpm |
| Engine Oil Temperature Model | 50 °C | 105 °C |
| Camshaft commanded position change (P00A/P00B) | 6.0 ° crank angle | |
| Delay time for actual Camshaft position change when commanded position is advanced or retarded (Table based on rpm and modeled oil temp) (P00A/P00B) | 0.95 seconds | 1.25 seconds |
| Camshaft commanded position steady (P0011/P0014) | | 0.75 ° crank angle |
| Camshaft commanded position steady for a required number of cam edges (Table based on rpm and modeled oil temp) (P0011/P0014) | 60 cam edges | 100 cam edges |
| Camshaft PWM Signal P0010/P0013) | 10 % | 100 % |

| Typical VVT Target Error/Slow Response malfunction thresholds: |
|---|
| P000A & P000B |
| Slow Response (Actual Camshaft position change): ≤ 1.875 deg crank intake, ≤ 4.125 deg crank exhaust |
| P0011 & P0014 |
| Target Error (Integrated difference between camshaft actual position and camshaft setpoint): ≥ 100 deg crank |
| P0010, P2088, P2089 & P0013, P2090, P2091 |
| Open Circuit detected by hardware driver circuit |

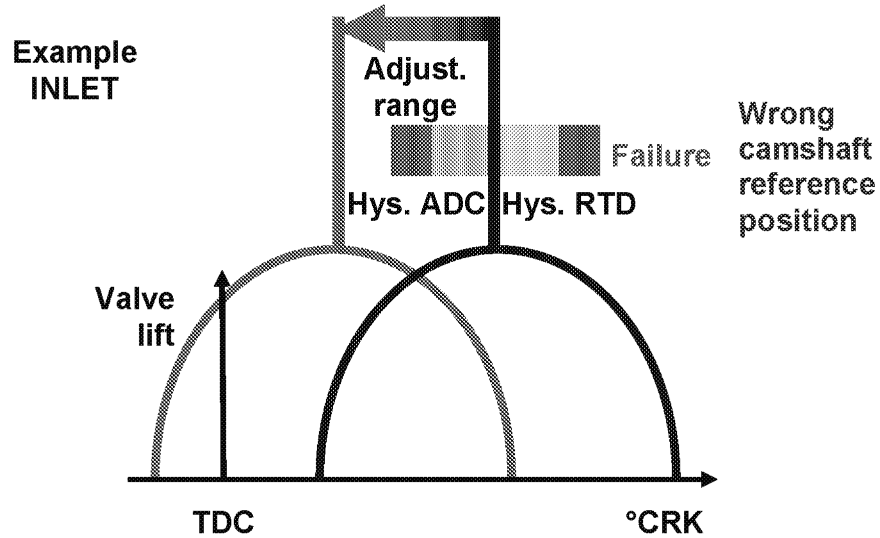
| J1979 VVT Monitor Mode $06 Data | | | |
|---|---|---|---|
| Monitor ID | Test ID | Description for CAN | Units |
| $35 | $B8 | Intake camshaft deviation at steady state | degrees |
| $35 | $B9 | Exhaust camshaft deviation at steady state | degrees |
| $35 | $BA | Intake camshaft deviation while changing state | degrees |
| $35 | $BB | Exhaust camshaft deviation while changing state | degrees |

## Camshaft/Crankshaft Position Correlation

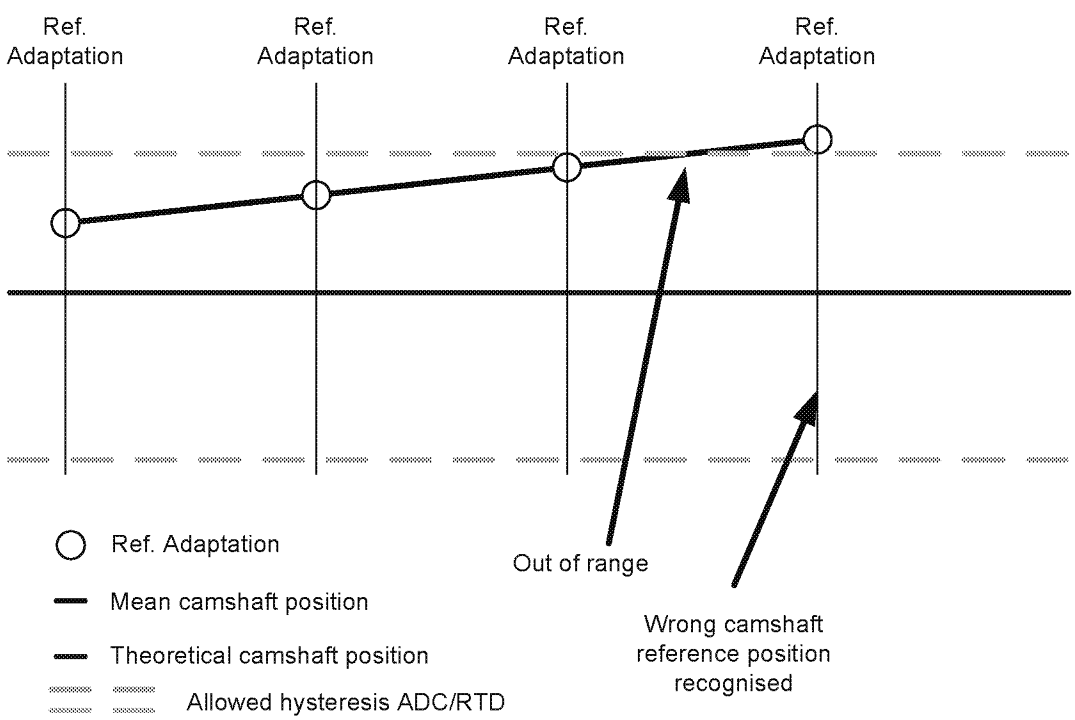
This diagnostic monitors whether the mean camshaft signal is within a plausible range during the reference position adaptation. The reference position adaptation is enabled if the target camshaft position is the reference one. This occurs after every engine start or during engine operation depending on the engine operating state.

A mean camshaft position is calculated from several camshaft signals. If the mean camshaft position is outside the hysteresis area, an incorrect camshaft reference position is detected. If this position is within the hysteresis, area, then there is no malfunction. After detecting a malfunction, an anti-bounce counter is incremented; otherwise the counter is decremented. If the counter exceeds an calibrated threshold, the appropriate DTC will be stored.

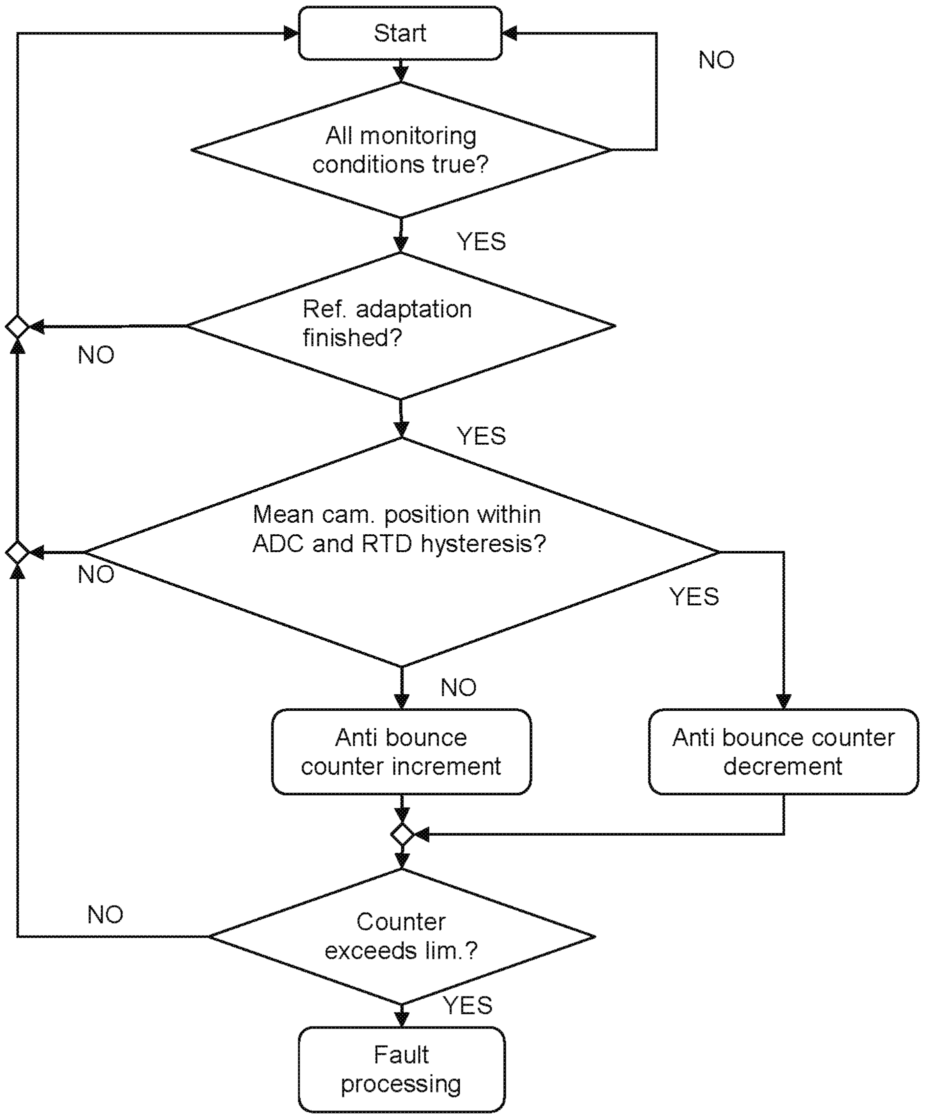
**Example 1:**




**Example 2:**



## Camshaft/Crankshaft Position Correlation



| VVT Camshaft/Crankshaft Position Correlation Monitor Operation: | |
|---|---|
| DTCs | P0016 - Crank/Cam Position Correlation (Bank 1 Sensor A)<br>P0017 - Crank/Cam Position Correlation (Bank 1 Sensor B) |
| Monitor execution | Continuous, with the exception of P052x codes which are only run during CSER operation |
| Monitor Sequence | None |
| Sensors OK | CMP |
| Monitoring Duration | 2160 crank degrees |

| Typical VVT Camshaft/Crankshaft Position Correlation monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| VVT active | | |
| CAM adaptation active | | |
| Engine speed | | 3296 rpm |
| Failure Time | 2160 ° crank angle | |

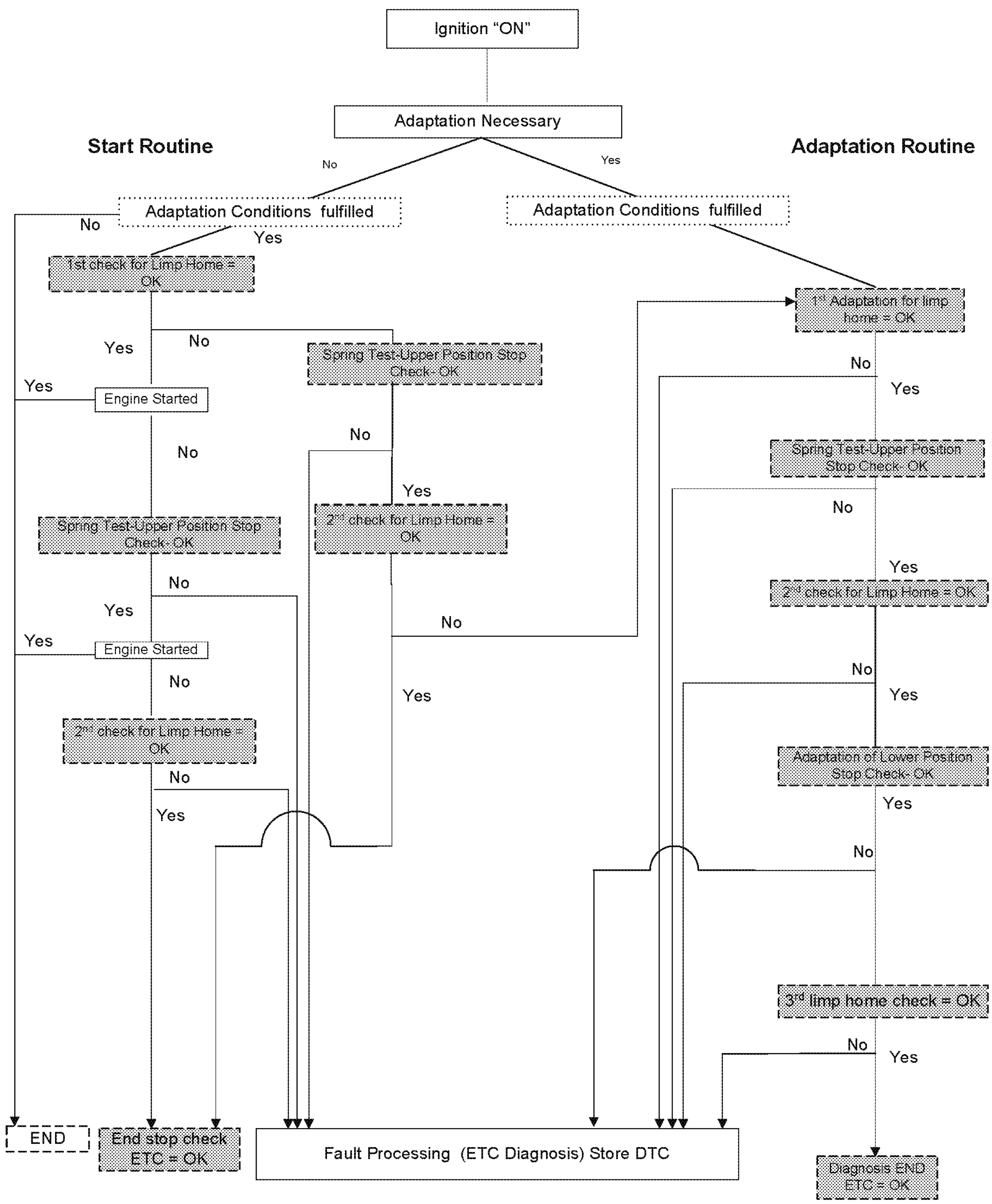
| Typical In-Use Performance monitoring thresholds: |
|---|
| P0016 |
| camshaft adapted reference position out of range: < -15 or > +15 deg crank |
| Excessive change in consecutive camshaft adaptations: > 15 deg crank |
| P0017 |
| camshaft adapted reference position out of range: < -15 or > +15 deg crank |
| Excessive change in consecutive camshaft adaptations: > 15 deg crank |

## Electronic Throttle Control

The Electronic Throttle Control (ETC) system uses a strategy that delivers engine or output shaft torque, based on driver demand, utilizing an electronically controlled throttle body. ETC strategy was developed mainly to improve fuel economy. This is possible by decoupling throttle angle (produces engine torque) from pedal position (driver demand). This allows the powertrain control strategy to optimize fuel control and transmission shift schedules while delivering the requested engine or wheel torque.

| ETC System Failure Mode and Effects Management: | |
|---|---|
| Effect | Failure Mode |
| No Effect on Drivability | A loss of redundancy or loss of a non-critical input could result in a fault that does not affect drivability. The ETC light will turn on, but the throttle control and torque control systems will function normally. |
| RPM Guard w/ Pedal Follower | In this mode, torque control is disabled due to the loss of a critical sensor or ECM fault. The throttle is controlled in pedal-follower mode as a function of the pedal position sensor input only. A maximum allowed RPM is determined based on pedal position (RPM Guard.) If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The ETC light and the MIL are turned on in this mode and the corresponding trouble code will be stored. |
| RPM Guard w/ Default Throttle | In this mode, the throttle plate control is disabled due to the loss of Throttle Position, the Throttle Plate Position Controller, or other major Electronic Throttle Body fault. A default command is sent to the TPPC, or the H-bridge is disabled. Depending on the fault detected, the throttle plate is controlled or springs to the default (limp home) position. A maximum allowed RPM is determined based on pedal position (RPM Guard.) If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The ETC light and the MIL are turned on in this mode and the corresponding trouble code will be stored. |
| RPM Guard w/ Forced High Idle | This mode is caused by the loss of 2 or 3 pedal position sensor inputs due to sensor, wiring, or ECM faults. The system is unable to determine driver demand, and the throttle is controlled to a fixed high idle airflow. There is no response to the driver input. The maximum allowed RPM is a fixed value (RPM Guard.) If the actual RPM exceeds this limit, spark and fuel are used to bring the RPM below the limit. The ETC light and the MIL are turned on in this mode and the corresponding trouble code will be stored. |
| Shutdown | If a significant processor fault is detected, the monitor will force vehicle shutdown by disabling all fuel injectors. The ETC light and the MIL are turned on in this mode and the corresponding trouble code will be stored.<br><br>Note: Vehicle shutdown does not increase emissions; therefore the MIL is not required to be illuminated for this fault. |
| | Note: ETC illuminates or displays a message on the message center immediately, MIL illuminates after 2 driving cycles |

## Throttle Actuator (ETC) (Controller Diagnosis)



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## Electronic Throttle Control (ETC) Motor Control Circuit

The ETC Motor Control Circuit diagnostics are able to detect a short circuit to power, a short circuit to ground and an open circuit. The diagnostic is initialized after a module reset or a “Key ON”. After initialization (Key "ON"), the following are all reset: The diagnostic conditions, the symptom, the counter, and the failure stored in the Error Management.

The circuit diagnostics execute every 10 milliseconds and are continuous. A short circuit can only be detected when the H-bridge switches are open, so the condition for the each short circuit is calculated during all ranges of the PWM.

The ETC motor control circuit diagnostic is activated between a battery voltage range. This is to eliminate false low limit voltage detection. The deactivation threshold for the ETC motor control circuit diagnostic is typically calibrated to a low voltage.

## Spring check (start routine)

This diagnostic checks if the throttle spring is working correctly and if the throttle limp home position can be achieved. The diagnostic is performed at the beginning of every driving cycle at ignition "Key ON" position. The throttle body spring check is executed as part of the start routine and is carried out with every “Key ON” of the engine control unit. More specifically the spring check is run during the TPS adaptation routine. The routine includes the following:

- Limp-home position check
- Adaptation of the limp-home position
- Upper return spring check

The start routine is only carried out when the adaptation conditions are maintained, (Key "ON" / Engine Running). The diagnostic will report when a spring-check error occurs, which includes the upper or lower return spring limits.

There is a throttle position set-point, calibratable, used for the upper return spring check. The TPS set-point should be approximately 10 ° greater than the limp-home position.

After the adaptation of the lower mechanical stop, the set point is used for the lower return spring check. The objective is to adjust the throttle in a position between the lower limit and limp-home. Without this set point, the throttle could stick in the lower mechanical stop after the adaptation. A typical value of 2 ° is recommended.

## ETC adaptation diagnostic

After the initial engine start and / or component change, the characteristic Potentiometer values for the limp home position and the lower mechanical stop are learned within an adaptation routine. The values are stored at the end of the driving cycle in the non-volatile memory. If the conditions are not fulfilled, the malfunction errors (DTC's) are stored.

Due to the electrical and mechanical tolerances of the ETC system, the sensor characteristic has to be learned and the ETC system controller must adapt. The TPS adaptation is executed as part of the start routine and is carried out the very first time there is a “Key ON” of the engine control unit at the vehicle assembly plant or when the engine control unit is changed in service.

The TPS adaptation includes the following functions:

- Adaptation and check of the limp-home position
- Adaptation and check of the lower mechanical stop
- Lower return spring check
- Adaptation of the amplifier amplification (TPS 1 channel)
- Upper return spring check

Due to the electrical and the mechanical tolerances of the throttle position system, the sensor characteristic has to be learned. The adaptation and diagnosis of the lower mechanical stop and limp-home position occurs within the adaptation routines. The adapted lower mechanical stop and the upper check position are used for the calculation of TPS channel 1. The upper mechanical stop is not learned. During the TPS adaptation no limitation of the throttle position set-point is active. The learned value for the limp-home position, the lower mechanical stop and the TPS channel1 values are stored at the end of each driving cycle as „non-volatile".

The first step is the adaptation of the limp-home position. The actuator is without current and is forced by spring power to the limp home position. During the adaptation all the voltage values must be in the adaptation windows. A hysteresis is set up around each of the first recorded values (TPS 1 and 2). If all the TPS values are with in this hysteresis during a calibrated time, then the adaptation values are determined from the first and last value for each TPS. If a TPS value is outside the hysteresis, then the process is started over for both TPS channels. The learning function is limited by a calibratable time. An adaptation error is detected if the adaptation could not be carried out during the maximum time.

The next step is the adaptation of the lower mechanical stop. The throttle is driven into the lower mechanical stop by switching on the position controller and gradually decreasing the set point. As soon as the mechanical stop is reached, the adaptation of the lower mechanical stop for all TPS input channels is started. The adaptation procedure is the same as the limp-home position except the calibration values are different. As with the limp-home position, if the maximum adaptation time is exceeded, an adaptation error is indicated.

Now the lower return spring is checked. The throttle is positioned between lower mechanical stop and limp-home by switching on the position controller and increasing the set point gradually until a calibrated set point for testing the lower return spring is reached. An adaptation error is indicated if the throttle does not reach the requested position in a defined time limit. Then the ETC power stage is switched off and the throttle has to return by spring power to the limp-home position or a return spring error is indicated.

Next is the adaptation of the amplification from the TPS measuring amplifier (TPS 1 channel). The controller is switched on and the set point is gradually increased and the throttle is moved to a position above limp-home until the calibrated set point for the adaptation of the measuring amplifier is reached. An adaptation error is indicated if the throttle does not reach the requested position in a defined time limit.

The final step is the check of the upper return spring. The throttle is gradually driven further away from limp home position until a calibrated set point for the upper spring check is reached. An adaptation error will be indicated if the throttle does not reach the requested position in a defined time limit. The ETC power stage is switched-off and the throttle has to return by spring power to the limp-home position, or an upper return spring error is indicated.

If all of the adaptations and checks pass, the learned value for the limp-home position, the lower mechanical stop and the TPS channel 1 values are stored at the end of each driving cycle in non-volatile memory. This provides the initial control settings for the next "Key ON".

## Electronic Throttle Control (ETC) Motor Control Performance

The task of this diagnostic is to detect a throttle valve error or a jammed ETC actuator. The diagnosis observes the ETC position controller system deviation dependent on the gradient of the throttle position setpoint. The anti-bounce of the error detection is done by the generic error management. The increment and decrement value of the anti-bounce counters can be calibrated.

Additionally the PWM output of the digital position controller is monitored by this diagnosis function. If the moving mean value exceeds a defined diagnosis threshold than an error will be indicated.

The diagnostic first observes the TPS sensor signal difference relative to the throttle position set point. If the difference is determined to be greater than a calibrated value, a control error is indicated. If the control system is unable to reach a set point within a calibrated time after multiple attempts, a jammed ETC actuator is indicated. In very low temperatures it is possible that the throttle actuator may become jammed by ice. If this is detected, an attempt to remove the ice will be made by varying the controller set point. The throttle position set point is varied by a rectangle function (Note: During active icebreaking engine speed limitation is requested!). If the ice-breaking is not successful after a defined number of pulses, the throttle position set point will be limited in lower or upper direction depending on the detected ice location. If the actual throttle position exceeds a defined threshold during limitation in the closed-throttle direction, then an additional error entry will be made with fault reaction of ETC power stage switch-off and engine speed limitation.

A second part of the diagnostic is to check the PWM output of the ETC system's position controller. If the moving-mean value of the PWM output exceeds a calibrated diagnostic threshold, then an error will be indicated.

| Throttle Plate Controller and Actuator Monitor Operation: | |
|---|---|
| DTCs | P2100 – throttle actuator circuit open, short to power, short to ground (MIL)<br><br>P2101 – throttle actuator range/performance test (MIL)<br><br>P2104 – throttle actuator stuck open/closed (MIL)<br><br>P2109 – throttle actuator sensor "A" minimum stop performance<br><br>P2118 – Over heat protection<br><br>P2119 – throttle body ice blockage (non-MIL)<br><br>P2176 - Minimum Throttle Position Not Learned<br><br>Note: For all the above DTCs, in addition to the MIL, the ETC light will be on for the fault that caused the FMEM action. |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | |
| Monitoring Duration | < 100 ms to register a malfunction |

| Typical Throttle Plate Controller and Actuator monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Ignition “ON” | | |
| Battery voltage | 11 V | 16 V |
| Engine speed (P2109) | 64 rpm | |
| Pedal Position (P2109) | | 5 % |
| ECT (P2109) | -30 °C | 105 °C |
| IAT (P2109) | -30 °C | |
| Vehicle Speed (P2109) | | 1.2 mph |
| Time since ignition on (P2109) | 1 s | |
| ECT (P2176) | 69.8 °C | |

**Typical In-Use Performance monitoring thresholds:**

P2100

ETC – open circuit detected by hardware driver circuit

P2101

Range / Performance detected by hardware driver circuit

P2104

TPS Stuck Throttle Blade - Open /Closed (Maximum permitted throttle position for the throttle position setpoint limitation): > 5 deg throttle

P2109

Adaptation values of lower mechanical stop out of range, Throttle position offset > .05 V

P2118

Over heat condition detected by hardware driver circuit

P2119

Pulsewidth from controller: > 90 %

TPS limit adaptation out of range: > - 60 %

MAF/TPS correlation, Actual vs. Model

Spring check - Lower position not reached during TPS adaptation: > - 60 deg

Spring check - Upper position not reached during TPS adaptation: > - 60 deg

P2176

Adaptation conditions exceeded / adaptation inhibited

## Accelerator and Throttle Position Sensor Inputs

| Accelerator Pedal Position Sensor Check Operation: | |
|---|---|
| DTCs | P2122, P2123 – APP D circuit continuity<br><br>P2138 – APP D/E circuit correlation<br><br>P2127, P2128 – APP E circuit continuity |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| APP sensor check malfunction thresholds: |
|---|
| APP D circuit continuity: frequency < 120 Hz or > 280 Hz<br>APP E circuit continuity: voltage < 4.644<br>APP D/E correlation : > 7% |

| Typical Throttle Position Sensor Check Operation: | |
|---|---|
| DTCs | P0122, P0123 – TP A circuit continuity<br>P0121 – TP A range/performance<br>P0222, P0223 – TP B circuit continuity |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | < 1 seconds to register a malfunction |

| Typical TP sensor check malfunction thresholds: |
|---|
| TP A circuit continuity - voltage < 0.04 volts or voltage > 4.7 volts<br>TP B circuit continuity - voltage < 0.32 volts or voltage > 4.95 volts<br>TP A Range/performance – modeled airflow/actual airflow disagree > 35% |

## Comprehensive Component Monitor - Engine

### Engine Temperature Sensor Input

Analog inputs such as Intake Air Temperature (P0112, P0113), Engine Coolant Temperature (P0117, P0118), Mass Air Flow (P0102, P0103), and Throttle Position (P0122, P0123) P0222, P0223) are checked for opens, shorts, or rationality by monitoring the analog -to-digital (A/D) input voltage.

| Engine Coolant Temperature Sensor Check Operation: | |
|---|---|
| DTCs | P0117 - Engine Coolant Temperature circuit low<br>P0118 - Engine Coolant Temperature circuit high |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical Engine Coolant Temperature Sensor Check monitor entry conditions: | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Intake air temperature OR | - 30 °C | |
| Time after engine start | 20 s | |

| Typical ECT sensor check malfunction thresholds: |
|---|
| P0117 Short to ground: < 0.03 V<br>P0118 Short to battery plus or open circuit: > 3.26 V |

| ECT Sensor Rationality Check Operation: | |
|---|---|
| DTCs | P0116 - Engine Coolant Temperature stuck high or stuck in range |
| Monitor execution | Once per driving cycle |
| Monitor Sequence | None |
| Sensors OK | ECT, IAT, AAT |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical ECT Sensor Rationality check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Engine coolant temp at start-up (stuck low) | | 45 °C |
| Time after Start (stuck low) | 5 s | |
| ECT model change since start (stuck low) | 0.75 to 35.25 °C | |
| Engine Off Time (stuck in range) | 240 min | |
| Battery Voltage (stuck in range) | 11 V | 16 V |
| Intake Air Temperature at start (stuck in range) | -30 °C | 80 °C |
| Ambient Air Temperature at start (stuck in range) | -30 °C | |
| Difference between AAT at start and IAT at start (stuck in range) | 8.25 °C | |

| Typical ECT sensor rationality check malfunction thresholds: |
|---|
| <u>ECT Stuck Low:</u><br>Actual vs. Model Temperature: > 3.75 to 71.25 °C<br><u>ECT stuck in range:</u><br>ECT and IAT difference at engine start: > 9.75 °C AND<br>Expected ECT at engine start: > a table value 9.75 to 60 °C |

## Intake Air Temperature Sensor Input

| Intake Air Temperature Sensor Check Operation: | |
|---|---|
| DTCs | P0112 – Intake Air Temperature circuit low<br>P0113 Intake Air Temperature circuit high<br>P0114 Intake Air Temperature circuit intermittent/erratic |
| Monitor execution | continuous |
| Monitor Sequence | None |
| Sensors OK | IAT |
| Monitoring Duration | 5 seconds to register a malfunction |

| Typical ECT Sensor Rationality check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Battery voltage | 11 V | 16 V |
| Minimum time after start | 3 s | |

| Typical IAT sensor check malfunction thresholds: |
|---|
| P0112 - Short to ground: ≤ 0.02 V<br>P0113 - Short to battery / Open circuit: ≥ 3.17 V<br>P0114 - Signal intermittent / Noisy (IAT difference from moving average): ≥ 8.25 °C |

## IAT Rationality Test

The IAT rationality test determines if the IAT sensor is producing an erroneous temperature indication within the normal range of IAT sensor input.

| Intake Air Temperature Sensor Cold Start Plausibility Check Operation: | |
|---|---|
| DTCs | P009A - Intake Air Temperature /Ambient Air Temperature Correlation |
| Monitor execution | Once per driving cycle, at start-up |
| Monitor Sequence | None |
| Sensors OK | P2610, P0113, P0112, P0114, P0111, P0073, P0072, P0074, P0118, P0117, P0119, P0116, P0500 |
| Monitoring Duration | Immediate or up to 30 minutes to register a malfunction |

| Typical Intake Air Temperature Sensor Cold Start Plausibility Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine off time | 6.7 h | |
| Abs \| Engine Coolant Temperature at start minus Intake Air Temp at start \| | | 18 °C |
| Block heater not present | | |
| engine run time | | 240 s |

| Typical IAT Sensor Cold Start Plausibility check malfunction thresholds: |
|---|
| P009A<br>Abs \| Ambient Air Temp minus Engine Coolant Temperature at start \| > 18 °C AND<br>Abs \| Ambient Air Temp minus Intake Air Temperature at start \| > 18 °C |

| Intake Air Temperature Sensor Plausibility (Hot) Check Operation: | |
|---|---|
| DTCs | P0111 - Intake Air Temperature Sensor 1 Circuit Range/Performance |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | ambient pressure, MAF, IAT, vehicle speed |
| Monitoring Duration | 100 ms to register a malfunction |

| Typical Intake Air Temperature Sensor Plausibility (Hot) Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Battery voltage | 11 V | 16 V |
| Low vehicle speed (rationality) | | 3 mph |
| High vehicle speed (rationality) | 36 mph | |
| Medium load (rationality) | 100 kg/h | |
| Low load (rationality) | | 100 kg/h |
| air mass flow integral value (rationality) | 4.6 | kg |
| ECT (stuck) | -9.75 °C | |
| IAT (stuck) | -9.75 °C | |
| Time since start (stuck) | 25 s | |
| Distance driven since start (stuck) | 6.25 miles | |

**Typical IAT Sensor Plausibility (Hot) check malfunction thresholds:**

If the P009A diagnostic enable conditions are met prior to exceeding maximum engine run time, the P011 test will not be run.

<u>P0111</u>

Rationality:

Expected Intake Air Temp decrease at low vehicle speed / low load: > 24.75 °C OR

Expected Intake Air Temp increase at high vehicle speed / medium load: > 24.75 °C

Stuck:

Change in IAT since engine start: < 1.5 °C

## Ambient Air Temperature Sensor Input

| Ambient Air Temperature Sensor Check Operation: | |
|---|---|
| DTCs | P0072 - Ambient Air Temperature circuit low<br>P0073 - Ambient Air Temperature circuit high |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | AAT, IAT |
| Monitoring Duration | 12.7 seconds to register a malfunction |

| Typical Ambient Air Temperature Sensor Plausibility Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| ECU power up time | 1.5 s | |

| Typical IAT sensor check malfunction thresholds: |
|---|
| P0072<br>Short to ground, open circuit: < 0.47 V<br>P0073<br>Short to battery: > 4.93 |

## Mass Air Flow Sensor

| MAF Sensor Check Operation: | |
|---|---|
| DTCs | P0102 (MAF low input)<br>P0103 (MAF high input) |
| Monitor execution | continuous |
| Monitor Sequence | none |
| Sensors OK | TPS, CKP |
| Monitoring Duration | 100 ms to register a malfunction |

| Typical Ambient Air Temperature Sensor Plausibility Entry Conditions | | |
|---|---|---|
| Entry condition | Minimum | Maximum |
| Engine speed (P0102 only) | 704 rpm | |
| Throttle position (P0102 only) | 0.503 deg | |
| DFCO not active (P0102 only) | | |

| Typical MAF sensor check malfunction thresholds: |
|---|
| P0102<br>Short to ground, open circuit: < 0.06 V<br>P0103<br>Short to battery: > 4.9 V |

## Mass Air Flow Range Performance

T

| TPS Load Check Operation: | |
|---|---|
| DTCs | P0101 |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | MAF, IAT, CPS, ambient sensor, TP,supply voltage, CAM, VVT, ECT |
| Monitoring Duration | 2.4 sec within test entry conditions |

| TPS Load Check Operation entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Closed Loop Fuel Control | Active | |
| Battery voltage | 10 V | |
| ECT | 70 deg C | |
| IAT | 15 deg C | |
| Engine run time | 30 s | |
| Filtered lambda correction | -30% | |
| Filtered lambda correction | | 30% |
| BARO | 75 kPa | 108 kPa |
| Engine speed (idle test) | 640 rpm | 1056 rpm |
| Throttle position (idle test) | 4 to 14 deg | |
| Engine speed (part throttle test) | 992 rpm | 4000 rpm |
| Throttle position (part throttle test) | 15 to 28 deg | |
| Normalized load (part throttle test) | 35% | 63% |

| Typical TPS Load Check Operation malfunction thresholds: |
|---|
| Actual Air Flow - Modeled Airflow for idle test > 30% AND lambda correction <-30% OR<br>Actual Air Flow - Modeled Airflow for idle test < 30% AND lambda correction >-30%<br><br>Actual Air Flow - Modeled Airflow for part throttle test > 18 to 25% AND lambda correction <-22.5% OR<br>Actual Air Flow - Modeled Airflow for part throttle test < 18 to -25% AND lambda correction > -22.5% |

## TPS Load Test

The MAF and TP sensors are cross-checked to determine whether the sensor readings are rational and appropriate for the current operating conditions. (P0068)

| TPS Load Check Operation: | |
|---|---|
| DTCs | P0068 |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | MAF, IAT, CPS, ambient sensor, TP,supply voltage, CAM, VVT, ECT |
| Monitoring Duration | 20 ms within test entry conditions |

| TPS Load Check Operation entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Closed Loop Fuel Control | Active | |
| Battery voltage | 10 V | |
| ECT | 70 deg C | |
| IAT | 15 deg C | |
| Engine run time | 30 s | |
| Filtered lambda correction | -22.5% | |
| Filtered lambda correction | | 22.5% |
| BARO | 75 kPa | 108 kPa |
| Engine speed (idle test) | 640 rpm | 1056 rpm |
| Throttle position (idle test) | 4 to 14 deg | |
| Engine speed (part throttle test) | 992 rpm | 4000 rpm |
| Throttle position (part throttle test) | 15 to 28 deg | |
| Normalized load (part throttle test) | 35% | 63% |

| Typical TPS Load Check Operation malfunction thresholds: |
|---|
| Actual Air Flow - Modeled Airflow for idle test < - 35% |
| Actual Air Flow - Modeled Airflow for part throttle test > 30.5 to 50% |
| Actual Air Flow - Modeled Airflow for part throttle test < -30.5 to -50% |

| 5 Volt Sensor Reference Voltage A Check: | |
|---|---|
| DTCs | P0642 (low input)<br>P0643 (high input) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 100 ms to register a malfunction |
| **5 Volt Sensor Reference Voltage B Check:** | |
| DTCs | P0652 (low input)<br>P0653 (high input) |
| Monitor execution | Continuous |
| Monitor Sequence | None |
| Sensors OK | not applicable |
| Monitoring Duration | 100 ms to register a malfunction |

| Typical 5 Volt Sensor Reference Voltage A & B check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition "ON" | NA | NA |

| Typical 5 Volt Sensor Reference Voltage A & B check malfunction thresholds: |
|---|
| P0642 & P0652<br>Short to ground (signal voltage): < 4.75 V<br>P0643 & P0653<br>Short to battery plus (signal voltage): > 5.25 V |

## Engine Off Timer Monitor

The engine off timer function is obtained via a CAN message from the instrument panel cluster. There are multiple parts to the diagnosis of the engine off timer.

The first engine off timer test (rationality) is based upon two signals received from other devices within the vehicle. The rationality test is based upon a comparison between the global real time transmitted by the instrument cluster and the engine off time which is transmitted either from the keyless vehicle module (if equipped) or from the cluster (if not equipped with keyless entry). The monitor makes these comparisons in the "key on engine running" state reflecting the timer's performance with the engine both on and off.

When vehicles are being shipped (transport mode) and during extended periods of no vehicle operation, the vehicle will be put into a low power mode in order to retain battery power. During this time, the engine controller is not supplied power, nor are many other devices on the vehicle; including the sources of the timers used for the rationality comparison. Therefore, the system will apply default time values for the initial drive cycle after re-awakening, inhibiting the diagnostic. The low power inhibition is only allowed for at most two consecutive key cycles.

A second test (out of range) is to ensure that the engine off time is not saturated. If the engine off time is saturated, but the global real time does not correspond with that saturated value, a P2610 fault will be set.

The last test (no signal) will trigger a P2610 when there is an absence of the signals over CAN.

| Engine Off Timer Check Operation: | |
|---|---|
| DTCs | P2610 |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Monitoring Duration | 1 s to 4 seconds to set malfunction depending on which failure. |

| Typical Engine Off Timer check malfunction thresholds: |
|---|
| Difference between engine off timer compared to Global Real Time > 327 s |
| Difference between time after start calculated by ECU and time after start calculated from Global Real Time clock: ≥ 2 - 10 min |
| Engine Off time from CAN > 300 s AND engine off time based on Global Real Time clock: < 6552 s |
| Engine off timer from CAN not available before engine start after two battery disconnects |

## Idle Speed Control Monitor

The Idle Speed Control system is functionally checked by monitoring the closed loop idle speed correction required to maintain the desired idle rpm. If the proper idle rpm cannot be maintained and the system has a high rpm (+200) or low rpm error (-100) greater than the malfunction threshold, an Idle Speed malfunction is indicated. (P0506, P0507) If an idle speed deviation occurs during cold start, a P050A will be stored as part of the cold start monitoring strategy.

| Idle Speed Check Operation: | |
|---|---|
| DTCs | P0506 (functional - under speed)<br>P0507 (functional - over speed) |
| Monitor execution | every idle condition |
| Monitor Sequence | None |
| Sensors OK | P0459, P0443, P0497, P0458, P0116, P0117, P0118, P0119, P0101, P0068, P0102, P0103 |
| Monitoring Duration | 3 seconds |

| Typical Idle Speed functional check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition “ON” | | |
| Canister purge | | 7.99 kg |
| MAF | | 240 m/s |
| ECT | 60 °C | |
| Engine Run Time | 100 s | |
| Torque control at limit | 2 s | |
| Battery voltage | 11 V | 16 V |
| Stabilization Period | 3 s | |

| Typical IAC functional check malfunction thresholds: |
|---|
| P0506<br>RPM Lower than Commanded (engine speed commanded minus actual engine speed): > 100 rpm<br>P0507<br>RPM Higher than Commanded (actual engine speed minus engine speed commanded): > 200 rpm |

**The ECM monitors the "smart" driver fault status bit that indicates either an open circuit, short to power or short to ground.**

| **Injector Check Operation:** | |
|---|---|
| DTCs | P0201 (Cyl 1 injector open)<br>P0261 (Cyl 1 injector low)<br>P0262 (Cyl 1 injector high)<br>P0202 (Cyl 2 injector open)<br>P0264 (Cyl 2 injector low)<br>P0265 (Cyl 2 injector high)<br>P0203 (Cyl 3 injector open)<br>P0267 (Cyl 3 injector low)<br>P0268 (Cyl 3 injector high)<br>P0204 (Cyl 4 injector open)<br>P0270 (Cyl 4 injector low)<br>P0271 (Cyl 4 injector high) |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Sensors OK | No injector errors |
| Monitoring Duration | 2 seconds |

| **Typical injector circuit check entry conditions:** | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition "ON" | | |

| **Typical injector circuit check malfunction thresholds:** |
|---|
| <u>P0201 & P0202 & P0204 & P0204</u><br>Open circuit: Error detection is performed by ECM circuit driver<br><u>P0261 & P0264 & P0267 & P0270</u><br>Short to ground: Error detection is performed by ECM circuit driver<br><u>P0262 & P0265 & P0268 & P0271</u><br>short to battery: Error detection is performed by ECM circuit driver |

## Knock Sensor

Two basic diagnostic tests are performed on each knock sensor – circuit continuity tests and a knock processing chip tests.

Due to the design of the knock sensor input circuitry, after filtering and integration, a short to battery, short to ground, or open circuit all result is a low knock signal voltage. This voltage is compared to a noise signal threshold (function of rpm) to determine knock sensor circuit high and circuit low faults.

Another indication of a sensor failure is the standard deviation of the signal noise which decreases when there is a failure. The knock signal standard deviation is compared to a threshold (function of rpm).

The knock signal processing chip SPI bus is checked to make sure it is not off. This would indicate there is no communication between the main processor and the chip used as the interface the knock sensor.

| Knock Sensor Check Operatio | |
|---|---|
| DTCs | P0325 – Knock Sensor 1 Circuit<br>P0326 – Knock Sensor 1 Circuit/Range Performance<br>P0330 – Knock Sensor 2 Circuit<br>P0331 – Knock Sensor 2 Circuit/Range Performance<br>P06B6 - Internal Control Module Knock Sensor Processor 1 Performance |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Sensors OK | P0326, P0330,P0331 |
| Monitoring Duration | 2.5 seconds |

| Typical Knock Sensor check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition "ON" | | |
| Engine Coolant Temperature | 42 °C | |
| Mass Air Flow | 158 mg/stroke | |
| Engine speed | 1088 rpm | |

| Typical Knock Sensor functional check malfunction thresholds: |
|---|
| P0325 & P0330<br>Knock signal too low (function of engine speed): < 0.3516 V<br>P0326 & P0331<br>Knock signal standard deviation too low (function of engine speed): < 0.0195 V to 0.0586V<br>P06B6<br>SPI bus failure |

## Barometric Pressure Sensor

The purpose of the diagnosis shall be to detect electrical faults as defined by OBD I requirements.
The signal of the altitude pressure sensor on the A/D-input of the microcontroller is checked.

| Barometric Pressure Sensor Check Operation: | |
|---|---|
| DTCs | P2227 – Barometric Pressure Sensor "A" Circuit Range/Performance<br>P2228 – Barometric Pressure Sensor "A" Circuit Low<br>P2229 – Barometric Pressure Sensor "A" Circuit High |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Sensors OK | TP, MAF, ECT, ambient pressure, supply voltage, VS |
| Monitoring Duration | 5 seconds |

| Typical Barometric Pressure Sensor check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition "ON" | | |
| Engine running | | |
| Vehicle speed | 0 mph | |
| Engine at Idle (closed throttle) | | |
| Mass air flow | | |
| Intake manifold pressure | 99.9 kPa | |
| Engine Coolant Temperature | -48 °C | |

| Typical Barometric Pressure Sensor functional check malfunction thresholds: |
|---|
| P2227<br>BARO gradient (Table Based on vehicle speed): > 10 kPa/s OR<br>BARO from last driving cycle minus BARO @engine start): > 10 kPa -AND-<br>mass air flow calculated from BARO sensor minus mass air flow): > 3 kg/h<br>P2228<br>Short to ground or open circuit: ≤ 0.85 V<br>P2229<br>Short to battery: ≥ 4.50 V |

## Ignition Coil

The purpose of this diagnosis function is to detect all major failures, which can happen between the ECU output and ignition coils.
The diagnosis is performed separate for each ignition coil. The feedback signal from the specific ignition coil (following the firing order) is evaluated by the microcontroller.

| Ignition Coil: | |
|---|---|
| DTCs | P0351 – Ignition Coil A Primary Control Circuit Open<br>P2301 – Ignition Coil A Primary Control Circuit High<br>P0352 – Ignition Coil B Primary Control Circuit Open<br>P2304 – Ignition Coil B Primary Control Circuit High |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Sensors OK | Oposite Coil errors |
| Monitoring Duration | 50 ms |

| Typical ignition circuit check malfunction thresholds: |
|---|
| P0351 & P0352<br>Open circuit: Error detection is performed by ECM circuit driver<br>P2301 & P2304<br>Short to battery: Error detection is performed by ECM circuit driver |

## Camshaft Position Sensor Monitor

A P0340/P0365 malfunction is indicated if no signal edge is detected for a calibratable time between two expected camshaft signal edges. A P0341/P0366 malfunction is indicated if the camshaft position is outside of the calibrated range specified for the engine. A P0344/P0369 malfunction is detected if a tooth segment period is too short.

| Camshaft Position Sensor: | |
|---|---|
| DTCs | P0340 – Camshaft Position Sensor "A" Circuit<br>P0341 – Camshaft Position Sensor "A" Circuit Range/Performance<br>P0344 – Camshaft Position Sensor "A" Circuit Intermittent<br>P0365 – Camshaft Position Sensor "B" Circuit<br>P0366 – Camshaft Position Sensor "B" Circuit Range/Performance<br>P0369 – Camshaft Position Sensor "B" Circuit Intermittent |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Sensors OK | CKP, CMP |
| Monitoring Duration | 4 engine cycles |

| Typical Camshaft Position check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition | On | |
| Engine speed | | 3712 rpm |

| Typical Camshaft Position check malfunction thresholds: |
|---|
| P0340 - Signal Implausible / Loss of Sync.<br>No signal edge is detected for a max time between two camshaft signal edges: > 4 counts<br>P0341 - Plausibility check<br>Number of missing camshaft edges seen from the previous camshaft edge: > 3<br>P0344 - Intermittent/erratic<br>Cam Segment Period to Short: > 3<br>P0365 - Signal Implausible / Loss of Sync.<br>No signal edge is detected for a max time between two camshaft signal edges: > 4 counts<br>P0366 - Plausibility check<br>Number of missing camshaft edges seen from the previous camshaft edge: > 3<br>P0369 - Intermittent/erratic<br>Cam Segment Period to Short: > 3 |

## Crankshaft Position Sensor Monitor

A P0335 malfunction is indicated if there is no crankshaft signal detected. A P0336 malfunction is indicated if a camshaft signal is present (engine is spinning) but a crankshaft signal is not present, or the number of teeth detected is incorrect, or if the time between teeth is implausible.

| Crankshaft Position Sensor: | |
|---|---|
| DTCs | P0335 – Crankshaft Position Sensor "A" Circuit<br>P0336 – Crankshaft Position Sensor "A" Circuit Range/Performance |
| Monitor execution | Continuous within entry conditions |
| Monitor Sequence | None |
| Sensors OK | CRK, CMP |
| Monitoring Duration | 12 ms |

| Typical Crankshaft Position check entry conditions: | | |
|---|---|---|
| Entry Condition | Minimum | Maximum |
| Ignition "ON" | | |
| Maximum engine speed to enable tooth number diagnosis | | 512 rpm |

| Typical Crankshaft Position check malfunction thresholds: |
|---|
| <u>P0335</u><br>Signal missing: No signal<br>Signal missing (Sensor signal voltage): > 2.487 V - OR - < 1.2199 V<br>Signal missing (Min and max difference between the voltage based on Engine speed): (Table based on engine speed) 2 V at 992 rpm and 3 V at 8000 rpm<br><u>P0336</u><br>Synchronization Error (Signal available):<br>Missing Teeth (Not enough teeth per CAM pulses):<br>Additional Teeth (two or more teeth seen per CAM pulses):<br>Signal Implausible / Loss of Sync. (Did not sync):<br>Crankshaft signal missing: No Signal |

## Miscellaneous CPU Tests

U0101 - Lost Communications With Transmission Control System (for vehicles with standalone TCM)

U0121 - Lost Communication With Anti-Lock Brake System (ABS) Control Module (for vehicles with manual trans)

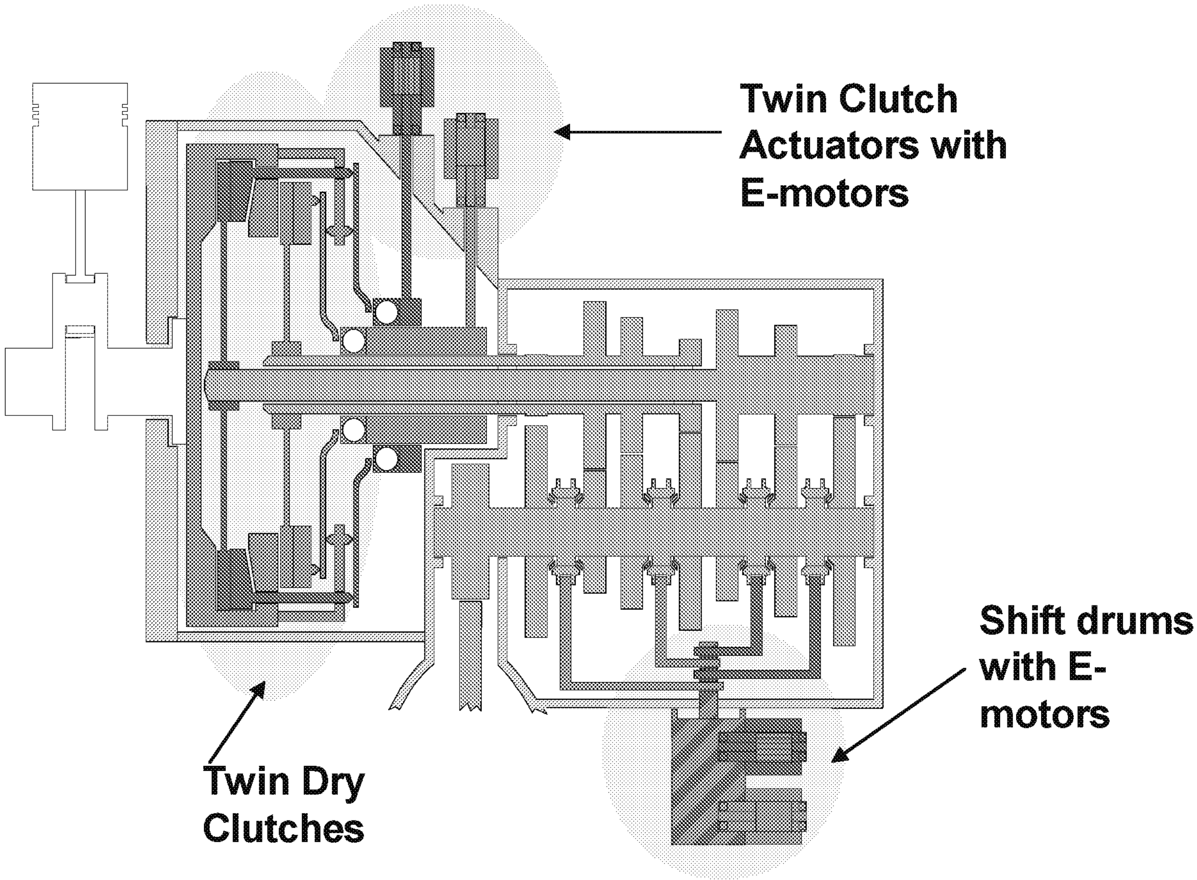
U0423 - Invalid Data Received from Instrument Panel Cluster Control Module

U2012 - Car Configuration Parameter(s) - vehicle configuration not plausible

## DPS6 (FWD) Transmission

DPS6 is a fully automatic 6 speed transmission made up of manual transmission gearing, combined with electro-mechanical actuators, and conventional automatic transmission controls.

### The Gearbox & Dual-Clutch System Physical Architecture




DPS6 has 2 clutches:

1. Clutch A – on in 1st, 3rd and 5th gear
2. Clutch B – on in Reverse, 2nd, 4th and 6th gear

Each clutch system consists of:

- Clutch
- 3 phase electric motor – rotates a screw driven fulcrum that controls clutch position (and torque). There are end stops at the full open and full closed positions
- Each motor phase has a hall position sensor that combine to provide a relative position – the system must sweep the clutch full open to full closed, then count increments on the sensors to know position. It takes many rotations of the motor to sweep the clutch from fully open to fully closed.
- Spring that returns the clutch to the full open position if the motor is turned off.

DPS6 has 2 shift drums:

1. Shift Drum A – controls the shift forks that engage $1^{st}$, $3^{rd}$ and $5^{th}$ gear
2. Shift Drum B – controls the shift forks that engage Reverse, $2^{nd}$, $4^{th}$ and $6^{th}$ gear

Each shift drum system consists of:

- Shift drum with groove that controls the position of shift forks
- Shift forks that engage synchronizers and gears
- 3 phase electric motor that controls the position of the shift drum
- Hall sensor system that knows the position of the motor within a rotation, used to calculate the shift drum angular position (the shift drum motor rotates 61.44 times for a single revolution of the shift drum)

Relationship between shift drum angle and gears;

| Angle | Shift drum 1 position | Shift drum 2 position |
|---|---|---|
| 0 deg | End stop near $1^{st}$ | End stop near Reverse |
| 10 deg | Centered in $1^{st}$ | Centered in Reverse |
| 55 deg | Neutral between $1^{st}$ and $3^{rd}$ | Neutral between R and $2^{nd}$ |
| 90 deg | Centered in $3^{rd}$ | Centered in $2^{nd}$ |
| 135 deg | Neutral between $3^{rd}$ and $5^{th}$ | Neutral between $2^{nd}$ and $4^{th}$ |
| 190 deg | Centered in $5^{th}$ | Centered in $4^{th}$ |
| 200 deg | End stop near $5^{th}$ | $4^{th}$ gear |
| 235 deg | | Neutral between $4^{th}$ and $6^{th}$ |
| 280 | | Centered in $6^{th}$ |
| 290 | | End stop near $6^{th}$ |

## Transmission Inputs

### Transmission Range Sensor

DPS6 is range by wire with mechanical Park. DPS6 uses a dual PWM output (at 250 Hz) TRS where one signal is the inverse of the other and the sum of the two signals add up to 100%. Each signal is tested for frequency errors (P0706 / P2801), duty cycle out of range low (P0707 / P2802) and duty cycle out of range high (P0708 / P2803). There is also a correlation error (P2805) if the two signals do not add up to 100%.

### Speed Sensors

Input 1 Speed Sensor (I1SS) – detects input shaft 1 speed, connected to clutch 1 and the odd gears (1st, 3rd and 5th). I1SS is tested for power supply faults (P06A6), circuit failures detected by the TCM hardware (P0715), erratic signal (P0716), and lack of signal (P0717).

Input 2 Speed Sensor (I2SS) – detects input shaft 2 speed, connected to clutch 2 and the even gears (R, 2nd, 4th and 6th). I2SS is tested for power supply faults (P06A7), circuit failures detected by the TCM hardware (P2765), erratic signal (P2766), and lack of signal (P2767).

Output Speed Sensor (OSS) – detects output speed. OSS is tested for power supply faults (P06A8), circuit failures detected by the TCM hardware (P0720), erratic signal (P0721), and lack of signal (P0722).

Note: because DPS6 is "Dry clutch" the only transmission fluid is for splash lube (no pump, no pressure control solenoids), so DPS6 does not have a temperature sensor.

## Transmission Outputs

DPS6 has four 3-phase electric motors:

1. Clutch A motor – controls clutch A torque capacity. The Clutch A system is tested for:
    a. ATIC faults (P0805) – the ATIC is an internal TCM component that controls motor current.
    b. Hall sensor faults (P0806) – each phase has a hall sensor that provides motor position information
    c. Sequence faults (P0809) – as the motor rotates it generates an defined pattern from the 3 hall sensors, if the sequence of hall sensor patterns is off this code sets.
    d. Open circuit (P0900)
    e. Short to ground (P0902)
    f. Short to power (P0903)
    g. Clutch functionally stuck off (P07A2)
    h. Clutch functionally stuck on (P07A3)

2. Clutch B motor – controls clutch B torque capacity. The Clutch B system is tested for:
    a. ATIC faults (P087A) – the ATIC is an internal TCM component that controls motor current.
    b. Hall sensor faults (P087B) – each phase has a hall sensor that provides motor position information
    c. Sequence faults (P087E) – as the motor rotates it generates an defined pattern from the 3 hall sensors, if the sequence of hall sensor patterns is off this code sets.
    d. Open circuit (P090A)
    e. Short to ground (P090C)
    f. Short to power (P090D)
    g. Clutch functionally stuck off (P07A4)
    h. Clutch functionally stuck on (P07A5)

3. Shift drum A motor – controls the shift forks that engage $1^{st}$, $3^{rd}$ and $5^{th}$ gear. The system is tested for:
   a. ATIC faults (P2831) – the ATIC is an internal TCM component that controls motor current.
   b. Sequence faults (P2835) – as the motor rotates it generates an defined pattern from the 3 hall sensors, if the sequence of hall sensor patterns is off this code sets.
   c. Open circuit (P285B)
   d. Short to ground (P285D)
   e. Short to power (P285E)
   f. Stuck in gear (P072C, P072E, P073A)
   g. Position error (P2832) – includes blocked motor, or any failure that results in the TCM losing confidence in the relative position of the shift drum.

4. Shift drum A motor – controls the shift forks that engage $1^{st}$, $3^{rd}$ and $5^{th}$ gear. The system is tested for:
   a. ATIC faults (P2836) – the ATIC is an internal TCM component that controls motor current.
   b. Sequence faults (P283A) – as the motor rotates it generates an defined pattern from the 3 hall sensors, if the sequence of hall sensor patterns is off this code sets.
   c. Open circuit (P285F)
   d. Short to ground (P2861)
   e. Short to power (P2862)
   f. Stuck in gear (P072B, P072D, P072F, P073B)
   g. Position error (P2837) – includes blocked motor, or any failure that results in the TCM losing confidence in the relative position of the shift drum.

## Transmission Control Module (TCM)

The TCM monitors itself by using various software monitoring functions. The TCM is monitored for:

a. If a RAM Read/Write error is detected during initialization, a P0604 fault code will be stored

b. the flash ROM is checked using a checksum calculation. If the checksum is incorrect during a P0605 fault will be stored

c. CPU performance is monitored for incorrect instructions or resets, if detected a P0607 fault code is set

d. If an error is found with NVRAM a P06B8 fault code will be stored

### CAN Communications error

The TCM receives information from the ECM via CAN. If the CAN link fails the TCM no longer has torque or engine speed information available. The TCM will store a U0073 fault code if the CAN Bus is off. The TCM will store a U0100 fault code if it doesn't receive any more CAN messages from the ECM. A U0401 fault codes will be stored if the ECM received invalid/faulted information for the following CAN message items: engine torque, pedal position.

System voltage:

the TCM monitors system voltage and stores fault codes if it is out of range low (P0882) or out of range high (P0883). These thresholds are set based on hardware capability.

## On Board Diagnostic Executive

The On-Board Diagnostic (OBD) Executive is a portion of the PCM strategy that manages the diagnostic trouble codes and operating modes for all diagnostic tests. It is the "traffic cop" of the diagnostic system. The Diagnostic Executive performs the following functions:

- Sequence the OBD monitors such that when a test runs, each input that it relies upon has already been tested. For 2008 MY and beyond ISO 14229 programs, the OBD monitors are no longer sequenced by the diagnostic executive.
- Controls and co-ordinates the execution of the individual OBD system monitors: Catalyst, Misfire, EGR, O2, Fuel, AIR, EVAP and, Comprehensive Component Monitor (CCM). For 2008 MY and beyond ISO 14229 programs, the execution of the OBD monitors is no longer controlled and coordinated by the diagnostic executive.
- Stores freeze frame and "similar condition" data.
- Manages storage and erasure of Diagnostic Trouble Codes as well as MIL illumination.
- Controls and co-ordinates the execution of the On-Demand tests: Key On Engine Off (KOEO) Key On Engine Running (KOER).
- Performs transitions between various states of the diagnostic and powertrain control system to minimize the effects on vehicle operation.
- Interfaces with the diagnostic test tools to provide diagnostic information (I/M readiness, various J1979 test modes) and responses to special diagnostic requests (J1979 Mode 08 and 09).
- Tracks and manages indication of the driving cycle which includes the time between two key on events that include an engine start and key off.

The diagnostic executive also controls several overall, global OBD entry conditions.
The battery voltage must fall between 11.0 and 18.0 volts to initiate monitoring cycles.
The engine must be started to initiate the engine started, engine running, and engine off monitoring cycles.
The Diagnostic Executive suspends OBD monitoring when battery voltage falls below 11.0 volts.
The Diagnostic Executive suspends monitoring of fuel-system related monitors (catalyst, misfire, evap, O2, AIR and fuel system) when fuel level falls below 15%. For 2005 MY and beyond, the execution of the fuel related OBD monitors is no longer suspended for fuel level by the diagnostic executive.

The diagnostic executive controls the setting and clearing of pending and confirmed DTCs.

A pending DTC and freeze frame data is stored after a fault is confirmed on the first monitoring cycle. If the fault recurs on the next driving cycle, a confirmed DTC is stored, freeze frame data is updated, and the MIL is illuminated. If confirmed fault free on the next driving cycle, the pending DTC and freeze frame data is erased on the next power-up.
Pending DTCs will be displayed as long as the fault is present. Note that OBD-II regulations required a complete fault-free monitoring cycle to occur before erasing a pending DTC. In practice, this means that a pending DTC is erased on the next power-up after a fault-free monitoring cycle.
After a confirmed DTC is stored and the MIL has been illuminated, three consecutive confirmed fault-free monitoring cycles must occur before the MIL can be extinguished on the next (fourth) power-up. After 40 engine warm-ups, the DTC and freeze frame data is erased.

The diagnostic executive controls the setting and clearing of permanent DTCs.

A permanent DTC is stored when a confirmed DTC is stored, the MIL has been illuminated, and there are not yet six permanent DTCs stored.
After a permanent DTC is stored, three consecutive confirmed fault-free monitoring cycles must occur before the permanent DTC can be erased.
After a permanent DTC is stored, one confirmed fault-free monitoring cycle must occur, following a DTC reset request, before the permanent DTC can be erased. For 2010MY and beyond ISO 14229 programs a driving cycle including the following criteria must also occur, following the DTC reset request, before a permanent DTC can be erased:

- Cumulative time since engine start is greater than or equal to 600 seconds;
- Cumulative vehicle operation at or above 25 miles per hour occurs for greater than or equal to 300 seconds (medium-duty vehicles with diesel engines certified on an engine dynamometer may use cumulative operation at or above 15% calculated load in lieu of at or above 25 miles per hour for purposes of this criteria); and
- Continuous vehicle operation at idle (i.e., accelerator pedal released by driver and vehicle speed less than or equal to one mile per hour) for greater than or equal to 30 seconds.

A permanent DTC can not be erased by a battery disconnect. Additionally, its confirmed DTC counterpart will be restored after completion of the system reset (battery reconnect).

## Exponentially Weighted Moving Average

Exponentially Weighted Moving Averaging is a well-documented statistical data processing technique that is used to reduce the variability on an incoming stream of data. Use of EWMA does not affect the mean of the data; however, it does affect the distribution of the data. Use of EWMA serves to "filter out" data points that exhibit excessive and unusual variability and could otherwise erroneously light the MIL.

The simplified mathematical equation for EWMA implemented in software is as follows:

New Average = [New data point * "filter constant"] + [( 1 - "filter constant" ) * Old Average]

This equation produces an exponential response to a step-change in the input data. The "Filter Constant" determines the time constant of the response. A large filter constant (i.e. 0.90) means that 90% of the new data point is averaged in with 10% of the old average. This produces a very fast response to a step change. Conversely, a small filter constant (i.e. 0.10) means that only 10% of the new data point is averaged in with 90% of the old average. This produces a slower response to a step change.

When EWMA is applied to a monitor, the new data point is the result from the latest monitor evaluation. A new average is calculated each time the monitor is evaluated and stored in Non Volatile Memory (NVRAM). This normally occurs each driving cycle. The MIL is illuminated and a DTC is stored based on the New Average store in NVRAM.

In order to facilitate repair verification and DDV demonstration, 2 different filter constants are used. A "fast filter constant" is used after are erased and a "normal filter constant" is used for normal customer driving. The "fast filter" is used for 2 driving cycles after DTCs are erased, and then the "normal filter" is used. The "fast filter" allows for easy repair verification and monitor demonstration in 2 driving cycles, while the normal filter is used to allow up to 6 driving cycles, on average, to properly identify a malfunction and illuminate the MIL. This feature is called Fast Initial Response (FIR). The fast filter is always calibrated to 1.0 which means that the EWMA is effectively disabled because the new average is 100% of the new data point. Since the EWMA is effectively disabled, it takes twp driving cycles to set the MIL. The first driving cycle with a fault will set a pending DTC; the second driving cycle will set a confirmed code and illuminate the MIL. This feature is called Fast Initial Response (FIR). The fast filter is always calibrated to 1.0 which means that the EWMA is effectively disabled because the new average is 100% of the new data point. Since the EWMA is effectively disabled, it takes twp driving cycles to set the MIL. The first driving cycle with a fault will set a pending DTC; the second driving cycle will set a confirmed code and illuminate the MIL.

The other unique feature used with EWMA is called Step Change Logic (SCL). This logic detects an abrupt change from a no-fault condition to a fault condition. This is done by comparing the new data point to the EWMA old average. If the two points differ by more than a calibrated amount (i.e. the new data point is outside the normal distribution), it means that a catastrophic failure has occurred. The fast filter is then used in the same manner as for the FIR feature above. Since the EWMA is effectively disabled, it takes twp driving cycles to set the MIL. The first driving cycle with a fault will set a pending DTC; the second driving cycle will set a confirmed code and illuminate the MIL. The SCL becomes active after the 4th "normal" monitoring cycle to give the EWMA a chance to stabilize.

During "normal" EWMA operation, a slower filter constant is used. The "normal filer" allows the MIL to be illuminated in 1 to 6 driving cycles. A confirmed code is set and the MIL is illuminated as soon as the EWMA crosses the malfunction threshold. There is no pending DTC because EWMA uses a 1-trip MIL.

In order to relate filter constants to driving cycles for MIL illumination, filter constants must be converted to time constants. The mathematical relationship is described below:

Time constant = [ ( 1 / filter constant ) - 1 ] * evaluation period

The evaluation period is a driving cycle. The time constant is the time it takes to achieve 68% of a step-change to an input. Two time constants achieve 95% of a step change input.

## EWMA Examples

EWMA with FIR and SCL has been incorporated in the IAF catalyst monitor, the Rear O2 response test and the EONV Evaporative system leak check monitor. There are 3 parameters that determine the MIL illumination characteristics.

"Fast" filter constant (0.9999), used for 2 driving cycles after DTCs are cleared (FIR) and for Step Change Logic (SCL)

"Normal" filter constant( typically 0.4), used for all subsequent, "normal" customer driving

Number of driving cycles to use fast filter after DTC clear (set to 2 driving cycles)

Several examples for a typical catalyst monitor calibration are shown in the tables below. The first example does not show SCL in order to better illustrate the EWMA calculation and the 1-trip MIL.

| Monitor evaluation ("new data") | EWMA Filter Calculation, "normal" filter constant set to 0.4 Malfunction threshold = .75 | Weighted Average ("new average") | Driving cycle number | Action/Comment |
|---|---|---|---|---|
| 0.15 | .15 * (0.4) + .15 * ( 1 - 0.4) | 0.15 | | normal 120K system |
| 1.0 | 1.0 * (0.4) + .15 * ( 1 - 0.4) | 0.49 | 1 | large failure occurs |
| 1.0 | 1.0 * (0.4) + .49 * ( 1 - 0.4) | 0.69 | 2 | |
| 1.0 | 1.0 * (0.4) + .69 * ( 1 - 0.4) | 0.82 | 3 | exceeds threshold, MIL on |
| 1.0 | 1.0 * (0.4) + .82 * ( 1 - 0.4) | 0.89 | 4 | MIL on |
| | | | | |
| 0.8 | 0.8 * (0.4) + .15 * ( 1 - 0.4) | 0.41 | 1 | 1.5 * threshold failure |
| 0.8 | 0.8 * (0.4) + .41 * ( 1 - 0.4) | 0.57 | 2 | |
| 0.8 | 0.8 * (0.4) + .57 * ( 1 - 0.4) | 0.66 | 3 | |
| 0.8 | 0.8 * (0.4) + .66 * ( 1 - 0.4) | 0.72 | 4 | |
| 0.8 | 0.8 * (0.4) + .72 * ( 1 - 0.4) | 0.75 | 5 | equals threshold, MIL on |
| 0.8 | 0.8 * (0.4) + .75 * ( 1 - 0.4) | 0.77 | 6 | MIL on |
| | | | | |
| 0.8 | 0.8 * (0.99) + 0* ( 1 - 0.99) | 0.8 | 1 | 1.5 * threshold failure after code clear, pending DTC |
| 0.8 | 0.8 * (0.99) + .8 * ( 1 - 0.99) | 0.8 | 2 | MIL on (I/M Readiness set to "ready" |

## I/M Readiness

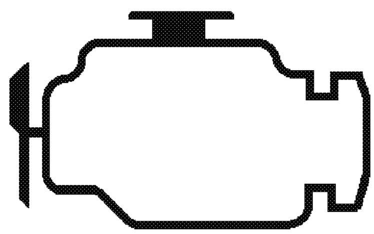
The readiness function is implemented based on the J1979 format. A battery disconnection or clearing codes using a scan tool results in the various I/M readiness bits being set to a "not-ready" condition. As each non-continuous monitor completes a full diagnostic check, the I/M readiness bit associated with that monitor is set to a "ready" condition. This may take one or two driving cycles based on whether malfunctions are detected or not. The readiness bits for comprehensive component monitoring, misfire and fuel system monitoring are immediately considered complete since they are continuous monitors.

## Serial Data Link MIL Illumination

The OBD-II diagnostic communication messages utilize an industry standard 500 kbps CAN communication link.

The instrument cluster on some vehicles uses the same CAN data link to receive and display various types of information from the ECM. For example, the engine coolant temperature information displayed on the instrument cluster comes from the same ECT sensor used by the ECM for all its internal calculations.

These same vehicles use the CAN data link to illuminate the MIL rather than a circuit, hard-wired to the ECM. The ECM periodically sends the instrument cluster a message that tells it to turn on the MIL, turn off the MIL or blink the MIL. If the instrument cluster fails to receive a message within a 5-second timeout period, the instrument cluster itself illuminates the MIL. If communication is restored, the instrument cluster turns off the MIL after 5 seconds. Due to its limited capabilities, the instrument cluster does not generate or store Diagnostic Trouble Codes.



## Closed Loop Fuel Control Enable Conditions

Closed loop fuel control is enabled (with a delay) at the start of a driving cycle and can be temporary inhibited (open loop) during the driving cycle. The turn-on delay at the start of a driving cycle is described by the following enable conditions:

- the upstream oxygen sensor is functional, i.e. the upstream HO2S' operating temperature has been reached
- a calibrated delay time, after end of engine start, has elapsed
- the engine coolant temperature (if used) must have exceeded a calibrated threshold or the modeled engine coolant temperature (substitute for a faulty temperature sensor minimum) must have exceeded a calibrated threshold after a calibrated period of time

Closed loop fuel operation is also inhibited during a driving cycle when any of the following conditions exist:

- During fuel cut-off or cylinder shut-off
- When catalyst over temperature protection is active.
- Full load enrichment active.
- When Catalyst purge is active.

Closed loop lambda control is inhibited during a driving cycle if any of the following errors exist:

- a catalyst damaging misfire rate
- Upstream HO2S sensor malfunction present

## Calculated Load Value

LOAD_PCT (PID $04) =

$$\frac{\text{current airflow}}{\text{(peak airflow at WOT@STP as a function of rpm)} * \text{(BARO/29.92)} * \text{SQRT(298/(AAT+273))}}$$

Where: STP = Standard Temperature and Pressure = 25 $^{o}$C, 29.92 in Hg BARO,
SQRT = square root,
WOT = wide open throttle,
AAT = Ambient Air Temperature and is in $^{o}$C

## OBD Connector Locations

Ford Motor Company's 2013 MY products comply with the location and means of access practices set forth in SAE J1962 and are in compliance with the location and means of access requirements of 40 CFR 86.094 and the California OBD II regulations.

# Ford Motor Company
## 2013 MY OBD Group Summary

| OBD II or HD OBD Group | Strategy Path | Test Group | Vehicle Line(s)<br>(market & exh. emissions std. for reference only) | ARB Selection Category | Latest Deficiency Status |
|---|---|---|---|---|---|
| Small Vehicle FWD (Continental Controls) | F35 | DFMXV01.6VDB | 1.6L Fiesta (B299N) TiVCT [50S-T2B4/ULEV2q] | Rep. Cal. | Diagnostic Connector, Sub-Feedback Fuel Control Monitoring |
| Small Vehicle FWD Direct Injection (DI) | HJB / HBB (U502 / U38X) | DFMXT02.02EC | 2.0L Explorer (U502) / Edge (U387) TiVCT GTDI [50S-T2B5/ULEV2] | Interim Rep. Cal | PCV Monitoring |
| | GHB | DFMXT01.62E9 | 1.6L Escape (C520) TiVCT GTDI [50S-T2B5/ULEV2] | | |
| | GFB | DFMXT02.02E1 | 2.0L Escape (C520) TiVCT GTDI [50S-T2B5/ULEV2] | | |
| | GDF | DFMXV02.0VE6 | 2.0L Taurus (D258) / MKT Livery (D472) TiVCT GTDI [50S-T2B5/ULEV2] | | |
| | HFC | DFMXV02.0VZ2<br>DFMXV02.0VE3 | 2.0L Focus (C346N) DI-TiVCT [50S-T2B3/SULEV2]<br>2.0L Focus (C346N) DI-TiVCT FFV [Fed-T2B5] | | |
| | GMB<br>HFC | DFMXV02.0VER<br>DFMXV02.0VD2 | 2.0L Focus (C346N) ST GTDI [50S-T2B5/ULEV2]<br>2.0L Focus (C346N) DI-TiVCT FFV [50S-T2B4/ULEV2q] | | |
| | GTF / GSW (CD391 / CD533) | DFMXV02.0VEY | 2.0L Fusion (CD391) / MKZ (CD533) TiVCT GTDI [50S-T2B5/ULEV2] | | |
| | GHF / GHM<br>(auto / man) | DFMXV01.6VZF<br>DFMXV01.6VDF | 1.6L Fusion (CD391) TiVCT GTDI [50S-T2B3/SULEV2]<br>1.6L Fusion (CD391) TiVCT GTDI [50S-T2B5/ULEV2] | Rep. Cal., DDV, PVE | PCV Monitoring, Purge Monitoring |
| Small Vehicle FWD Port Fuel Injection (PFI) | JZD | DFMXT02.52ET | 2.5L Escape (C520) iVCT [50S-T2B5/ULEV2] | Interim Rep. Cal., PVE | Fuel System Monitor (A/F Cylinder Imbalance) |
| | FVJ | DFMXT02.01DW | 2.0L Transit Connect (V227N) [50S-T2B4/ULEV2q] | Separate submission | Catalyst System Monitor, Permanent Fault Code (6F35 Trans), Rear Oxygen Sensor Response Monitoring |
| | CDF | DFMXV02.5VEX | 2.5L Fusion (CD391) iVCT [50S-T2B5/ULEV2] | Rep. Cal. | Fuel System Monitor (A/F Cylinder Imbalance) |

## Ford Motor Company
## 2013 MY OBD Group Summary

| OBD II or HD OBD Group | Strategy Path | Test Group | Vehicle Line(s)<br>(market & exh. emissions std. for reference only) | ARB Selection Category | Latest Deficiency Status |
|---|---|---|---|---|---|
| Large Vehicle/ Crossover Utility Vehicle (CUV) FWD PFI | KNC | DFMXT03.72EE | 3.5 & 3.7L Edge (U387) & 3.7L MKX (U388) TiVCT [50S-T2B5/ULEV2] | Rep. Cal. | None |
| | KMD | DFMXT03.73E8 | 3.5L Explorer (U502) & 3.7L Explorer Police? (U502) TiVCT [50S-T2B5/ULEV2] | | |
| | | DFMXT03.73DM | 3.5L Explorer (U502) FFV & 3.7L Explorer Police (U502) TiVCT FFV [Fed-T2B5] | | |
| | KHC (non-CD533) / CHF (CD533 only) | DFMXV03.7VE8 | 3.5L Taurus (D258) / Taurus Police (D258) / Flex (D471) & 3.7L Taurus Police (D258) / MKZ (CD533) / MKS (D385) / MKT (D472) / MKT Livery (D472) TiVCT [50S-T2B5/ULEV2] | | |
| | | DFMXV03.5VEA | 3.5L Taurus (D258) / Taurus Police (D258) & 3.7L Taurus Police (D258) TiVCT FFV [Fed-T2B5] | | |
| | KRC | DFMXV03.7VHJ | 3.7L MKT (D472) Limo / Hearse TiVCT [50S-T2B8/LEV2] | | |
| | JXA / JXC | DTKXV03.75BA | 3.7L Mazda 6 (J61L) iVCT [50S-T2B5/ULEV2] | | |
| | JXA | DTKXT03.75BA | 3.7L Mazda CX-9 (J50S) iVCT [50S-T2B5/ULEV2] | | |
| Large Vehicle/CUV FWD DI | KHD (Non-U502) / KJD (U502) | DFMXV03.5VEP | 3.5L Taurus (D258) / Taurus Police (D258) / MKS (D385) / Flex (D471) / MKT (D472) / Explorer (U502) iVCT GTDI [50S-T2B5/ULEV2] | Rep. Cal. | Misfire Monitor - Disabled Blinking MIL (KJD only @ R21), PCV Monitoring |
| Large Car RWD | FGF | DFMXV05.8VE2 | 5.8L Mustang [50S-T2B5/LEV2] | Rep. Cal. | Misfire Monitor - Cylinder Identification, Diagnostic Connector |
| | FNF, FMF | DFMXV03.7VDT | 3.7L Mustang (S197) TiVCT [50S-T2B4/ULEV2q] | | Diagnostic Connector |
| | FSF / FPF, FPR | DFMXV05.0VD5 | 5.0L Mustang (S197) TiVCT [50S-T2B4/ULEV2q] | | Diagnostic Connector |
| Hybrid Electric Vehicle | HGK (CD) / HGP (C344N) | DFMXV02.0VZL | 2.0L Fusion (CD391) / MKZ (CD533) / C-Max (C344N) FHEV [50S-T2B3/ULEV2q] | Rep. Cal., PVE | None |
| Plug-In Hybrid Electric Vehicle | HPF (CD) / HGV (C344N) | DFMXV02.0VZP | 2.0L Fusion (CD391) / C-Max (C344N) PHEV [50S-T2B3/SULEV2] | Rep. Cal., DDV, PVE | Battery Pack Cooling Fan Monitoring, Fault Code Assignments for Comprehensive Components, Regenerative Braking Disablement, and Battery Pack Current Sensors<br>(vehicles produced afer Nov 12, 2012) |

# Ford Motor Company
## 2013 MY OBD Group Summary

| OBD II or HD OBD Group | Strategy Path | Test Group | Vehicle Line(s) (market & exh. emissions std. for reference only) | ARB Selection Category | Latest Deficiency Status |
|---|---|---|---|---|---|
| Large Truck | KGC | DFMXT03.54DX | 3.5L F-150 (P415) TiVCT GTDI [50S-T2B5/LEV2] | Rep. Cal., PVE | Misfire Monitor - Cold Disablement, PCV Monitoring, Purge Monitoring |
| | KPC | DFMXT03.73DP | 3.7L F-150 (P415) TiVCT FFV [50S-T2B4/ULEV2q] | | None |
| | KTC | DFMXT05.03D7 | 5.0L F-150 (P415) TiVCT FFV [50S-T2B4/ULEV2q] | DDV, PVE | Fuel System Monitor (A/F Cylinder Imbalance) |
| | BBH | DFMXT06.24D2 | 6.2L F-150 (P415) SVT Raptor / Harley [50S-T2B4/ULEV2q] | | None |
| | BRB | DFMXT06.27HL | 6.2L F-series Super Duty (P473) FFV [50S-T2B8/ULEV2q] | | None |
| | RXH | DFMXT05.44BC | 5.4L Expedition (U222) / Navigator (U228) / Exp. Max (U354) / Nav. L (U418) 3V FFV [50S-T2B4/ULEV2q] | | None |
| | | DFMXT05.44HY | 5.4L Expedition (U222) / Navigator (U228) / Exp. Max (U354) / Nav. L (U418) 3V FFV [Fed-T2B8] | | None |
| | | DFMXT05.45BR | 5.4L Exp. Max (U354) / Nav. L (U418) Limo FFV [50S-T2B8/ULEV2q] | | None |
| | TXA | DFMXT04.65H9 | 4.6L E-series MDPV and non-MDPV FFV (VN127) [50S-T2B8/ULEV2q] | | None |
| | | DFMXT05.45HK | 5.4L E-series (VN127) MDPV and non-MDPV FFV [50S-T2B8/ULEV2q] | | None |
| | | DFMXT05.45HL | 5.4L E-series (VN127) MDPV and non-MDPV Ambulance [50S-T2B8/ULEV2q] | | None |
| | TSA, TXA | DFMXE05.4AFD | 5.4L E-series (VN127) FFV <14K [50S-edHDGasFIN/edULEV2] | | None |
| | TSA | DFMXE05.4AFF | 5.4L E-series (VN127) Ambulance <14K [50S-edHDGasFIN/edULEV2] | | None |
| | TFC | DFMXT06.85HT | 6.8L E-series (VN127) MDPV and non-MDPV [50S-T2B8/ULEV2q] | | None |
| | | DFMXE06.8AFA | 6.8L E-series (VN127) <14K [50S-edHDGasFIN/edULEV2] | | None |
| Diesel OBD II (Bosch Controls) | DDC | DFMXD06.771C | 6.7L F-series Super Duty (P473) Diesel Comp. >10K [50S-chHDDsFIN-(0.4)/ULEV2] | Rep. Cal. | Particulate Matter Filter Monitor, Fuel System Injection Quantity and Timing Control Diagnostic, Idle Control System Diagnostic, Thermostat Diagnostic |
| | | DFMXD06.761A | 6.7L F-series Super Duty (P473) Diesel Comp. <10K [50S-chHDDsFIN-(0.2)/ULEV2] | | Particulate Matter Filter Monitor, Fuel System Injection Quantity and Timing Control Diagnostic, Idle Control System Diagnostic, Thermostat Diagnostic, and NMHC Catalyst Diagnostic |
| | | DFMXH06.7A24 | 6.7L F-series Super Duty (P473) Diesel Incomp. <14K [50S-edHDDsFIN/edULEV2] | | Particulate Matter Fillter Monitor, Idle Control System Diagnostic, Thermostat Diagnostic, SCR Catalyst Diagnostic, and Nox Sensor Diagnostic |
| HD OBD Diesel | DDC | DFMXH06.7B23 | 6.7L F-series Super Duty (P473) Diesel Incomp. >14K [50S-edHDDsFIN/edHDDsFIN] | Rep. Cal., DDV, PVE | Idle Control System Diagnostic, Thermostat Diagnostic, SCR Catalyst Diagnostic, and Nox Sensor Diagnostic |
| HD OBD Gasoline | TEZ (F-Series)<br>TFZ (F53/F59) | DFMXE06.8BW5 | 6.8L F-series Super Duty / Motorhome / Step Van 3V Inc. >14K (P473/F53/F59/H561) ) [50S-edHDGasFIN/edHDGasFIN] | Rep. Cal. | None |
| | TSA | DFMXE05.4BWC | 5.4L E-series (VN127) FFV >14K [50S-edHDGasFIN/edHDGasFIN] | Interim Rep. Cal. | None |
| | | DFMXE05.4BWL | 5.4L E-series (VN127) Ambulance >14K [50S-edHDGasFIN/edHDGasFIN] | | |
| | TFC | DFMXE06.8BWX | 6.8L E-series (VN127) >14K [50S-edHDGasFIN/edHDGasFIN] | | |

**NOTES:**

Rep. Cal.: Representative Calibration
DDV: Durability Demonstration Test Vehicl
PVE: Production Evaluation Vehicle

Rear Wheel Drive :RWD
Front Wheel Drive :FWD
Heavy Duty :HD

# Index for Single Roll Settings 2013 Model Year Car

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Fiesta*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Fiesta TRLHP Chart_1 | 7/15/2011 | 2012 Manual Fiesta 3.2 percent Co | 43 | Carryover from 2012 |
| 2013 Fiesta TRLHP Chart_2 | 8/20/2012 | 2012 Manual Fiesta 3.2 percent Co | 43 | Added HK P185/60R15 Tire |

| Vehicle Description | | | | | | | Track Coefficients | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 3 Term coefs | | |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| Fiesta 4 DR | 1.6l | Man | FWD | P 185 60R 15 KU | 2750 | 10.1 | 16.83 | 16.28 | 0.2936 | 0.01795 |
| | | | | | 2875 | 10.3 | 17.33 | 17.24 | 0.2986 | 0.01794 |
| | | | | | 3000 | 10.4 | 17.80 | 18.20 | 0.3036 | 0.01793 |
| | | | | | 3250 | 10.7 | 18.71 | 20.12 | 0.3136 | 0.01792 |
| Fiesta 4 DR | 1.6l | Man | FWD | P 185 60R 15 HK | 2750 | 9.8 | 17.34 | 13.74 | 0.2965 | 0.01803 |
| | | | | | 2875 | 10.0 | 17.84 | 14.66 | 0.3022 | 0.01802 |
| | | | | | 3000 | 10.1 | 18.32 | 15.59 | 0.3079 | 0.01801 |
| | | | | | 3250 | 10.5 | 19.23 | 17.46 | 0.3194 | 0.01800 |
| Fiesta 4 DR | 1.6l | Man | FWD | P 195 50R 16 | 2750 | 10.2 | 16.68 | 16.46 | 0.2868 | 0.01829 |
| | | | | | 2875 | 10.4 | 17.16 | 17.48 | 0.2916 | 0.01828 |
| | | | | | 3000 | 10.5 | 17.62 | 18.51 | 0.2965 | 0.01828 |
| | | | | | 3250 | 10.9 | 18.49 | 20.58 | 0.3063 | 0.01827 |
| Fiesta 5 DR | 1.6l | Man | FWD | P 185 60R 15 KU | 2750 | 10.3 | 16.53 | 16.28 | 0.2936 | 0.01850 |
| | | | | | 2875 | 10.5 | 17.02 | 17.24 | 0.2986 | 0.01850 |
| | | | | | 3000 | 10.6 | 17.49 | 18.20 | 0.3036 | 0.01849 |
| | | | | | 3250 | 10.9 | 18.40 | 20.12 | 0.3136 | 0.01847 |
| Fiesta 5 DR | 1.6l | Man | FWD | P 185 60R 15 HK | 2750 | 10.0 | 17.03 | 13.74 | 0.2965 | 0.01858 |
| | | | | | 2875 | 10.2 | 17.52 | 14.66 | 0.3022 | 0.01857 |
| | | | | | 3000 | 10.3 | 17.99 | 15.59 | 0.3079 | 0.01857 |
| | | | | | 3250 | 10.6 | 18.90 | 17.46 | 0.3194 | 0.01855 |
| Fiesta 4 DR | 1.6l | Man | FWD | P 195 50R 16 | 2750 | 10.6 | 15.99 | 16.46 | 0.2868 | 0.01962 |
| | | | | | 2875 | 10.8 | 16.46 | 17.48 | 0.2916 | 0.01961 |
| | | | | | 3000 | 11.0 | 16.91 | 18.51 | 0.2965 | 0.01960 |
| | | | | | 3250 | 11.3 | 17.77 | 20.58 | 0.3063 | 0.01959 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Fiesta*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Fiesta TRLHP Chart_1 | 7/15/2011 | 2012 Auto Fiesta 1.6 percent Constant forc | 43 | Carryover from 2012 |
| 2013 Fiesta TRLHP Chart_2 | 8/20/2012 | 2013 Auto Fiesta 1.6 percent Constant forc | 43 | Added HK P185/60R15 Tire |

| Vehicle Description | | | | | | | Track Coefficients | | 3 Term coefs | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| Fiesta 4 DR | 1.6l | Auto | FWD | P 185 60R 15 KU | 2750 | 10.4 | 16.41 | 18.33 | 0.2716 | 0.01834 |
| | | | | | 2875 | 10.5 | 16.90 | 19.28 | 0.2766 | 0.01833 |
| | | | | | 3000 | 10.7 | 17.37 | 20.24 | 0.2816 | 0.01833 |
| | | | | | 3250 | 11.0 | 18.27 | 22.16 | 0.2916 | 0.01831 |
| Fiesta 4 DR | 1.6l | Auto | FWD | P 185 60R 15 HK | 2750 | 10.1 | 16.90 | 15.79 | 0.2745 | 0.01842 |
| | | | | | 2875 | 10.2 | 17.39 | 16.71 | 0.2802 | 0.01841 |
| | | | | | 3000 | 10.4 | 17.87 | 17.63 | 0.2859 | 0.01840 |
| | | | | | 3250 | 10.7 | 18.77 | 19.51 | 0.2974 | 0.01839 |
| Fiesta 4 DR | 1.6l | Auto | FWD | P 195 50R 16 | 2750 | 10.5 | 16.27 | 18.51 | 0.2649 | 0.01868 |
| | | | | | 2875 | 10.6 | 16.74 | 19.53 | 0.2697 | 0.01867 |
| | | | | | 3000 | 10.8 | 17.19 | 20.56 | 0.2746 | 0.01867 |
| | | | | | 3250 | 11.1 | 18.06 | 22.63 | 0.2844 | 0.01865 |
| Fiesta 4 DR SFEP | 1.6l | Auto | FWD | P 195 60R 15 | 2750 | 9.6 | 17.73 | 15.62 | 0.2460 | 0.01763 |
| | | | | | 2875 | 9.7 | 18.27 | 16.58 | 0.2503 | 0.01762 |
| | | | | | 3000 | 9.9 | 18.77 | 17.39 | 0.2546 | 0.01762 |
| | | | | | 3250 | 10.2 | 19.75 | 19.17 | 0.2634 | 0.01761 |
| Fiesta 5 DR | 1.6l | Auto | FWD | P 185 60R 15 KU | 2750 | 10.6 | 16.12 | 18.33 | 0.2716 | 0.01890 |
| | | | | | 2875 | 10.7 | 16.61 | 19.28 | 0.2766 | 0.01889 |
| | | | | | 3000 | 10.9 | 17.08 | 20.24 | 0.2816 | 0.01888 |
| | | | | | 3250 | 11.2 | 17.97 | 22.16 | 0.2916 | 0.01886 |
| Fiesta 5 DR | 1.6l | Auto | FWD | P 185 60R 15 HK | 2750 | 10.3 | 16.60 | 15.79 | 0.2745 | 0.01897 |
| | | | | | 2875 | 10.4 | 17.09 | 16.71 | 0.2802 | 0.01896 |
| | | | | | 3000 | 10.6 | 17.56 | 17.63 | 0.2859 | 0.01896 |
| | | | | | 3250 | 10.9 | 18.45 | 19.51 | 0.2974 | 0.01895 |
| Fiesta 5 DR | 1.6l | Auto | FWD | P 195 50R 16 | 2750 | 10.9 | 15.61 | 18.51 | 0.2649 | 0.02001 |
| | | | | | 2875 | 11.1 | 16.07 | 19.53 | 0.2697 | 0.02000 |
| | | | | | 3000 | 11.2 | 16.52 | 20.56 | 0.2746 | 0.01999 |
| | | | | | 3250 | 11.6 | 17.37 | 22.63 | 0.2844 | 0.01998 |
| Fiesta 5 DR SFEP | 1.6l | Auto | FWD | P 195 60R 15 | 2750 | 9.9 | 17.15 | 15.62 | 0.2460 | 0.01862 |
| | | | | | 2875 | 10.1 | 17.66 | 16.58 | 0.2503 | 0.01862 |
| | | | | | 3000 | 10.2 | 18.17 | 17.39 | 0.2546 | 0.01861 |
| | | | | | 3250 | 10.5 | 19.13 | 19.17 | 0.2634 | 0.01860 |

# ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Flex_MKT*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Flex MKT | 2/13/12 | Flex_MKT fwd, awd, livery, limo | 44 | Tires updated, new track, V44 |
| 2013 Flex MKT | 3/8/2012 | | | Corrected Hearse tire, + 6500lb for Limo |
| 2013 Flex MKT | 10/18/12 | | | Job1 + 90 tire added |

| | | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Description | | | | | | 3-Term | | 3 Term coefs | | |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| Flex_D471 | 3.5L | Auto | AWD | P 235 60R 18 GD | 4750 | 16.5 | 17.79 | 22.77 | 0.9163 | 0.02211 |
| | | | | | 5000 | 16.8 | 18.42 | 24.47 | 0.9221 | 0.02214 |
| | | | | | 5250 | 17.1 | 19.03 | 26.17 | 0.9280 | 0.02217 |
| | | | | P 235 55R 19 Ha | 4750 | 17.1 | 17.16 | 26.76 | 0.9572 | 0.02151 |
| | | | | | 5000 | 17.4 | 17.74 | 28.71 | 0.9656 | 0.02150 |
| | | | | | 5250 | 17.7 | 18.29 | 30.66 | 0.9741 | 0.02150 |
| | | | | P 255 45R 20 GD | 4750 | 16.9 | 17.36 | 27.20 | 0.9154 | 0.02157 |
| | | | | | 5000 | 17.2 | 17.93 | 29.31 | 0.9215 | 0.02157 |
| | | | | | 5250 | 17.6 | 18.48 | 31.43 | 0.9276 | 0.02158 |
| | | | | P 255 45R 20 Ha | 4750 | 17.1 | 17.18 | 26.53 | 0.9681 | 0.02131 |
| | | | | | 5000 | 17.4 | 17.77 | 28.44 | 0.9766 | 0.02130 |
| | | | | | 5250 | 17.7 | 18.33 | 30.36 | 0.9851 | 0.02129 |
| Flex_D471 | 3.5L | Auto | FWD | P 235 60R 17 Ha | 4750 | 15.7 | 18.72 | 16.88 | 0.8222 | 0.02394 |
| | | | | | 5000 | 16.0 | 19.30 | 18.57 | 0.8343 | 0.02398 |
| | | | | | 5250 | 16.4 | 19.87 | 20.27 | 0.8465 | 0.02402 |
| | | | | P 235 60R 18 GD | 4750 | 15.0 | 19.55 | 18.09 | 0.6709 | 0.02446 |
| | | | | | 5000 | 15.3 | 20.21 | 19.79 | 0.6767 | 0.02449 |
| | | | | | 5250 | 15.6 | 20.84 | 21.49 | 0.6826 | 0.02452 |
| | | | | P 235 55R 19 Ha | 4750 | 15.6 | 18.79 | 22.10 | 0.7106 | 0.02387 |
| | | | | | 5000 | 16.0 | 19.39 | 24.05 | 0.7189 | 0.02387 |
| | | | | | 5250 | 16.3 | 19.96 | 26.00 | 0.7273 | 0.02386 |
| | | | | P 255 45R 20 Ha | 4750 | 15.6 | 18.83 | 21.84 | 0.7216 | 0.02367 |
| | | | | | 5000 | 15.9 | 19.43 | 23.75 | 0.7301 | 0.02366 |
| | | | | | 5250 | 16.2 | 20.01 | 25.67 | 0.7386 | 0.02365 |
| Flex_D471 | 3.5L_GTDi | Auto | AWD | P 235 60R 18 GD | 4750 | 16.3 | 18.02 | 29.88 | 0.4639 | 0.02769 |
| | | | | | 5000 | 16.6 | 18.65 | 31.58 | 0.4698 | 0.02772 |
| | | | | | 5250 | 16.9 | 19.26 | 33.29 | 0.4757 | 0.02775 |
| | | | | P 235 55R 19 Ha | 4750 | 16.9 | 17.37 | 33.86 | 0.5072 | 0.02704 |
| | | | | | 5000 | 17.2 | 17.95 | 35.80 | 0.5156 | 0.02704 |
| | | | | | 5250 | 17.5 | 18.51 | 37.75 | 0.5241 | 0.02703 |
| | | | | P 255 45R 20 GD | 4750 | 16.7 | 17.58 | 34.33 | 0.4610 | 0.02718 |
| | | | | | 5000 | 17.0 | 18.15 | 36.44 | 0.4670 | 0.02719 |
| | | | | | 5250 | 17.4 | 18.70 | 38.56 | 0.4731 | 0.02719 |
| | | | | P 255 45R 20 Ha | 4750 | 16.9 | 17.39 | 33.66 | 0.5136 | 0.02693 |
| | | | | | 5000 | 17.2 | 17.98 | 35.57 | 0.5221 | 0.02692 |
| | | | | | 5250 | 17.5 | 18.54 | 37.49 | 0.5307 | 0.02691 |
| MKT_D472 | 3.7L | Auto | FWD | P 235 55R 19 Ha | 4750 | 15.2 | 19.35 | 21.67 | 0.7088 | 0.02272 |
| | | | | 36 psi | 5000 | 15.5 | 19.96 | 23.59 | 0.7170 | 0.02272 |
| | | | | | 5250 | 15.8 | 20.55 | 25.51 | 0.7252 | 0.02271 |
| | | | | P 255 45R 20 GD | 4750 | 15.1 | 19.52 | 22.51 | 0.6689 | 0.02278 |
| | | | | | 5000 | 15.4 | 20.12 | 24.62 | 0.6750 | 0.02278 |
| | | | | | 5250 | 15.7 | 20.68 | 26.74 | 0.6811 | 0.02279 |
| | | | | P 255 45R 20 Ha | 4750 | 15.2 | 19.30 | 21.84 | 0.7216 | 0.02252 |
| | | | | | 5000 | 15.5 | 19.91 | 23.75 | 0.7301 | 0.02251 |
| | | | | | 5250 | 15.8 | 20.49 | 25.67 | 0.7386 | 0.02250 |
| MKT_D472 | 3.5L_GTDi | Auto | AWD | P 235 55R 19 Ha | 4750 | 16.6 | 17.69 | 33.86 | 0.5072 | 0.02612 |
| | | | | | 5000 | 16.9 | 18.28 | 35.80 | 0.5156 | 0.02611 |
| | | | | | 5250 | 17.2 | 18.84 | 37.75 | 0.5241 | 0.02611 |
| | | | | P 255 45R 20 GD | 4750 | 16.5 | 17.84 | 34.73 | 0.4621 | 0.02626 |
| | | | | | 5000 | 16.8 | 18.41 | 36.87 | 0.4683 | 0.02626 |
| | | | | | 5250 | 17.1 | 18.96 | 39.01 | 0.4744 | 0.02627 |
| | | | | P 255 45R 20 GD | 4750 | 16.8 | 17.48 | 34.70 | 0.5176 | 0.02619 |
| | | | | J1 + 90 | 5000 | 17.1 | 18.04 | 36.77 | 0.5264 | 0.02618 |
| | | | | | 5250 | 17.5 | 18.57 | 38.84 | 0.5352 | 0.02618 |
| | | | | P 255 45R 20 Ha | 4750 | 16.6 | 17.72 | 33.66 | 0.5136 | 0.02600 |
| | | | | | 5000 | 16.9 | 18.31 | 35.57 | 0.5221 | 0.02599 |
| | | | | | 5250 | 17.2 | 18.87 | 37.49 | 0.5307 | 0.02598 |
| MKT_D472 | 2.0 GTDI | 6F35 | FWD | P 235 60R 18 GD | 4750 | 15.3 | 19.23 | 25.87 | 0.4276 | 0.02695 |
| | | | | | 5000 | 15.6 | 19.89 | 27.57 | 0.4334 | 0.02698 |
| | | | | | 5250 | 15.8 | 20.51 | 29.28 | 0.4393 | 0.02701 |
| MKT_D472 | 3.7L | Auto | AWD | P 235 60R 18 GY | 5000 | 16.5 | 18.76 | 24.47 | 0.9221 | 0.02122 |
| Livery | | | | | 5250 | 16.8 | 19.37 | 26.17 | 0.9280 | 0.02125 |
| Hearse 34.2ft^2 | | | | P 255 55R 18 Lim | 6000 | 18.9 | 19.60 | 34.49 | 0.9925 | 0.02313 |

# ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Flex_MKT*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Flex MKT | 2/13/12 | Flex_MKT fwd, awd, livery, limo | 44 | Tires updated, new track, V44 |
| 2013 Flex MKT | 3/8/2012 | | | Corrected Hearse tire, + 6500lb for Limo |
| 2013 Flex MKT | 10/18/12 | | | Job1 + 90 tire added |

| Vehicle Description | | | | | | Single Roll Settings 3-Term | | 3 Term coefs | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| Limo | | | | | 6500 | 18.6 | 21.63 | 38.21 | 1.0082 | 0.02026 |
| Limo | | | | | 7000 | 19.2 | 22.57 | 41.95 | 1.0239 | 0.02024 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Focus*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Focus TRLHP Chart_1 | 6/21/2012 | With latest aero 2013 Focus AGS Au | 45 | Manual PV Data & New track results used<br>Latest Aero used |
| 2013 Focus TRLHP Chart_2 | 10/9/2012 | New 17 inch tire added with latest ae | 45 | New 17" Cooper tire added |

| Vehicle Description | | | | | | | | Track Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| AGS 4DR | All | Man | FWD | 195 65R 15 | 2875 | 10.1 | 17.60 | 20.41 | 0.3137 | 0.01588 |
| | | | | | 3000 | 10.2 | 18.16 | 21.18 | 0.3148 | 0.01588 |
| | | | | | 3250 | 10.4 | 19.26 | 22.71 | 0.3169 | 0.01588 |
| | | | | | 3375 | 10.5 | 19.79 | 23.48 | 0.3179 | 0.01588 |
| | | | | | 3500 | 10.7 | 20.31 | 24.25 | 0.3190 | 0.01588 |
| | | | | 215 55R 16 | 2875 | 10.2 | 17.49 | 20.94 | 0.2962 | 0.01621 |
| | | | | | 3000 | 10.3 | 18.06 | 21.68 | 0.2967 | 0.01622 |
| | | | | | 3250 | 10.5 | 19.17 | 23.14 | 0.2975 | 0.01624 |
| | | | | | 3375 | 10.6 | 19.72 | 23.87 | 0.2980 | 0.01625 |
| | | | | | 3500 | 10.7 | 20.25 | 24.60 | 0.2984 | 0.01626 |
| | | | | 215 50R 17 | 2875 | 10.3 | 17.31 | 21.26 | 0.3053 | 0.01621 |
| | | | | | 3000 | 10.4 | 17.86 | 22.06 | 0.3063 | 0.01622 |
| | | | | | 3250 | 10.6 | 18.92 | 23.67 | 0.3082 | 0.01624 |
| | | | | | 3375 | 10.7 | 19.43 | 24.47 | 0.3092 | 0.01625 |
| | | | | | 3500 | 10.9 | 19.93 | 25.27 | 0.3102 | 0.01626 |
| | | | | 215 50R 17 | 2875 | 9.9 | 18.02 | 28.77 | 0.0457 | 0.01716 |
| | | | | Cooper | 3000 | 10.0 | 18.49 | 29.82 | 0.0503 | 0.01715 |
| | | | | | 3250 | 10.4 | 19.38 | 31.94 | 0.0594 | 0.01713 |
| | | | | | 3375 | 10.5 | 19.79 | 33.00 | 0.0640 | 0.01713 |
| | | | | | 3500 | 10.7 | 20.20 | 34.06 | 0.0686 | 0.01712 |
| | | | | 235 40R 18 | 2875 | 10.4 | 17.14 | 22.80 | 0.3040 | 0.01592 |
| | | | | | 3000 | 10.5 | 17.66 | 23.76 | 0.3049 | 0.01592 |
| | | | | | 3250 | 10.8 | 18.65 | 25.68 | 0.3068 | 0.01592 |
| | | | | | 3375 | 10.9 | 19.13 | 26.64 | 0.3078 | 0.01591 |
| | | | | | 3500 | 11.0 | 19.59 | 27.61 | 0.3088 | 0.01591 |
| AGS 5DR | All | Man | FWD | 195 65R 15 | 2875 | 10.5 | 16.94 | 20.33 | 0.3204 | 0.01696 |
| | | | | | 3000 | 10.6 | 17.49 | 21.10 | 0.3215 | 0.01696 |
| | | | | | 3250 | 10.8 | 18.57 | 22.63 | 0.3236 | 0.01696 |
| | | | | | 3375 | 10.9 | 19.09 | 23.39 | 0.3246 | 0.01696 |
| | | | | | 3500 | 11.0 | 19.60 | 24.16 | 0.3257 | 0.01696 |
| | | | | 215 55R 16 | 2875 | 10.6 | 16.85 | 20.85 | 0.3029 | 0.01728 |
| | | | | | 3000 | 10.7 | 17.40 | 21.59 | 0.3033 | 0.01729 |
| | | | | | 3250 | 10.9 | 18.48 | 23.06 | 0.3042 | 0.01732 |
| | | | | | 3375 | 11.0 | 19.01 | 23.79 | 0.3046 | 0.01733 |
| | | | | | 3500 | 11.1 | 19.53 | 24.52 | 0.3051 | 0.01734 |
| | | | | 215 50R 17 | 2875 | 10.7 | 16.68 | 21.17 | 0.3120 | 0.01728 |
| | | | | | 3000 | 10.8 | 17.21 | 21.98 | 0.3130 | 0.01729 |
| | | | | | 3250 | 11.0 | 18.25 | 23.58 | 0.3149 | 0.01732 |
| | | | | | 3375 | 11.1 | 18.75 | 24.38 | 0.3159 | 0.01733 |
| | | | | | 3500 | 11.2 | 19.24 | 25.18 | 0.3168 | 0.01734 |
| | | | | 215 50R 17 | 2875 | 10.2 | 17.40 | 28.77 | 0.0457 | 0.01823 |
| | | | | Cooper | 3000 | 10.4 | 17.86 | 29.82 | 0.0503 | 0.01822 |
| | | | | | 3250 | 10.7 | 18.73 | 31.94 | 0.0594 | 0.01821 |
| | | | | | 3375 | 10.9 | 19.15 | 33.00 | 0.0640 | 0.01820 |
| | | | | | 3500 | 11.1 | 19.55 | 34.06 | 0.0686 | 0.01819 |
| | | | | 235 40R 18 | 2875 | 10.8 | 16.52 | 22.72 | 0.3106 | 0.01700 |
| | | | | | 3000 | 10.9 | 17.02 | 23.67 | 0.3116 | 0.01700 |
| | | | | | 3250 | 11.2 | 18.00 | 25.59 | 0.3135 | 0.01699 |
| | | | | | 3375 | 11.3 | 18.46 | 26.56 | 0.3145 | 0.01699 |
| | | | | | 3500 | 11.4 | 18.92 | 27.52 | 0.3154 | 0.01699 |
| ST AGS 5DR | All | Man | FWD | 235 40R 18 | 2875 | 11.2 | 15.83 | 24.09 | 0.3190 | 0.01769 |
| | | | | | 3000 | 11.4 | 16.32 | 25.04 | 0.3201 | 0.01769 |
| | | | | | 3250 | 11.6 | 17.27 | 26.93 | 0.3222 | 0.01769 |
| | | | | | 3375 | 11.8 | 17.73 | 27.88 | 0.3233 | 0.01769 |
| | | | | | 3500 | 11.9 | 18.19 | 28.82 | 0.3244 | 0.01768 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Focus*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Focus TRLHP Chart_1 | 6/21/2012 | With latest aero 2013 Focus AG | 45 | Auto PV Data & New track results used<br>Latest Aero used<br>2012 A1 used which is based on no trans shift drum movement |
| 2013 Focus TRLHP Chart_2 | 10/9/2012 | New 17 inch tire added with lat | 45 | New 17" Cooper tire added |

| Vehicle Description | | | | | | | | Track Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Body** | **Eng** | **Trans** | **Drive** | **Tire** | **ETW** | **HP@50** | **55-45 CDT** | **f0** | **f1** | **f2** |
| AGS 4DR | All | Dps6 | FWD | 195 65R 15 | 2875 | 10.0 | 17.87 | 18.00 | 0.3542 | 0.01558 |
| | | | | | 3000 | 10.1 | 18.44 | 18.77 | 0.3552 | 0.01558 |
| | | | | | 3250 | 10.3 | 19.55 | 20.30 | 0.3573 | 0.01558 |
| | | | | | 3375 | 10.4 | 20.09 | 21.06 | 0.3584 | 0.01558 |
| | | | | | 3500 | 10.5 | 20.62 | 21.83 | 0.3594 | 0.01558 |
| | | | | 215 55R 16 | 2875 | 10.0 | 17.76 | 18.55 | 0.3357 | 0.01591 |
| | | | | | 3000 | 10.1 | 18.34 | 19.29 | 0.3361 | 0.01593 |
| | | | | | 3250 | 10.3 | 19.46 | 20.76 | 0.3370 | 0.01595 |
| | | | | | 3375 | 10.4 | 20.01 | 21.49 | 0.3374 | 0.01596 |
| | | | | | 3500 | 10.5 | 20.54 | 22.22 | 0.3378 | 0.01597 |
| | | | | 215 50R 17 | 2875 | 10.1 | 17.57 | 18.89 | 0.3444 | 0.01592 |
| | | | | | 3000 | 10.2 | 18.13 | 19.69 | 0.3453 | 0.01593 |
| | | | | | 3250 | 10.5 | 19.20 | 21.29 | 0.3473 | 0.01595 |
| | | | | | 3375 | 10.6 | 19.71 | 22.10 | 0.3482 | 0.01596 |
| | | | | | 3500 | 10.7 | 20.22 | 22.90 | 0.3492 | 0.01597 |
| | | | | 215 50R 17 | 2875 | 9.7 | 18.28 | 26.71 | 0.0784 | 0.01692 |
| | | | | Cooper | 3000 | 9.9 | 18.75 | 27.76 | 0.0830 | 0.01691 |
| | | | | | 3250 | 10.2 | 19.64 | 29.88 | 0.0922 | 0.01689 |
| | | | | | 3375 | 10.4 | 20.06 | 30.94 | 0.0968 | 0.01688 |
| | | | | | 3500 | 10.6 | 20.47 | 32.00 | 0.1014 | 0.01687 |
| | | | | 235 40R 18 | 2875 | 10.2 | 17.40 | 20.43 | 0.3432 | 0.01563 |
| | | | | | 3000 | 10.4 | 17.92 | 21.38 | 0.3441 | 0.01563 |
| | | | | | 3250 | 10.6 | 18.92 | 23.30 | 0.3460 | 0.01563 |
| | | | | | 3375 | 10.8 | 19.40 | 24.27 | 0.3470 | 0.01562 |
| | | | | | 3500 | 10.9 | 19.87 | 25.23 | 0.3480 | 0.01562 |
| AGS 5DR | All | Dps6 | FWD | 195 65R 15 | 2875 | 10.3 | 17.20 | 17.91 | 0.3608 | 0.01666 |
| | | | | | 3000 | 10.5 | 17.75 | 18.68 | 0.3619 | 0.01666 |
| | | | | | 3250 | 10.7 | 18.84 | 20.21 | 0.3640 | 0.01666 |
| | | | | | 3375 | 10.8 | 19.36 | 20.98 | 0.3650 | 0.01666 |
| | | | | | 3500 | 10.9 | 19.88 | 21.74 | 0.3661 | 0.01666 |
| | | | | 215 55R 16 | 2875 | 10.4 | 17.09 | 18.46 | 0.3424 | 0.01699 |
| | | | | | 3000 | 10.5 | 17.66 | 19.20 | 0.3428 | 0.01700 |
| | | | | | 3250 | 10.7 | 18.76 | 20.67 | 0.3437 | 0.01702 |
| | | | | | 3375 | 10.8 | 19.29 | 21.40 | 0.3441 | 0.01703 |
| | | | | | 3500 | 10.9 | 19.81 | 22.13 | 0.3445 | 0.01704 |
| | | | | 215 50R 17 | 2875 | 10.5 | 16.92 | 18.80 | 0.3510 | 0.01700 |
| | | | | | 3000 | 10.6 | 17.46 | 19.60 | 0.3520 | 0.01701 |
| | | | | | 3250 | 10.9 | 18.51 | 21.21 | 0.3539 | 0.01703 |
| | | | | | 3375 | 11.0 | 19.01 | 22.01 | 0.3549 | 0.01704 |
| | | | | | 3500 | 11.1 | 19.51 | 22.81 | 0.3559 | 0.01705 |
| | | | | 215 50R 17 | 2875 | 10.1 | 17.64 | 26.71 | 0.0784 | 0.01799 |
| | | | | Cooper | 3000 | 10.2 | 18.10 | 27.76 | 0.0830 | 0.01798 |
| | | | | | 3250 | 10.6 | 18.98 | 29.88 | 0.0922 | 0.01796 |
| | | | | | 3375 | 10.8 | 19.40 | 30.94 | 0.0968 | 0.01795 |
| | | | | | 3500 | 10.9 | 19.80 | 32.00 | 0.1014 | 0.01794 |
| | | | | 235 40R 18 | 2875 | 10.6 | 16.76 | 20.34 | 0.3498 | 0.01671 |
| | | | | | 3000 | 10.7 | 17.27 | 21.30 | 0.3508 | 0.01671 |
| | | | | | 3250 | 11.0 | 18.25 | 23.21 | 0.3527 | 0.01670 |
| | | | | | 3375 | 11.1 | 18.72 | 24.18 | 0.3537 | 0.01670 |
| | | | | | 3500 | 11.3 | 19.18 | 25.15 | 0.3546 | 0.01670 |
| SFE AGS | All | Auto | FWD | 215 55R 16 LR | 2875 | 9.3 | 19.07 | 14.09 | 0.3389 | 0.01558 |
| | | | | | 3000 | 9.4 | 19.72 | 14.66 | 0.3396 | 0.01559 |
| | | | | | 3250 | 9.6 | 20.99 | 15.81 | 0.3410 | 0.01561 |
| | | | | | 3375 | 9.7 | 21.59 | 16.39 | 0.3417 | 0.01563 |
| | | | | | 3500 | 9.8 | 22.20 | 16.96 | 0.3424 | 0.01564 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Focus*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Focus TRLHP Chart_1 | 6/28/2011 | 2013 Focus Non AGS All Co | 43 | Carryover from 2012 |
| | | 2013 Focus Historical TRLHP Non AGS New Track1.xls | | |
| 2013 Focus TRLHP Chart_1 | 7/11/2011 | 2013 Focus Non AGS All Co | 43 | Added 3500 ETW for ST |
| | | 2013 Focus Historical TRLF | 43 | |

| | Vehicle Description | | | | | | | | Track Coefficients | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| Non AGS 4DR | All | Manual | FWD | 195 65R 15 | 2875 | 10.5 | 16.89 | 22.40 | 0.2047 | 0.01855 |
| | | | | | 3000 | 10.7 | 17.36 | 23.35 | 0.2092 | 0.01854 |
| | | | | | 3250 | 11.0 | 18.28 | 25.25 | 0.2183 | 0.01852 |
| | | | | | 3375 | 11.1 | 18.72 | 26.20 | 0.2228 | 0.01851 |
| | | | | | 3500 | 11.3 | 19.15 | 27.14 | 0.2273 | 0.01851 |
| | | | | 215 55R 16 | 2875 | 10.6 | 16.74 | 23.20 | 0.1821 | 0.01896 |
| | | | | | 3000 | 10.8 | 17.22 | 24.11 | 0.1855 | 0.01897 |
| | | | | | 3250 | 11.1 | 18.16 | 25.94 | 0.1923 | 0.01899 |
| | | | | | 3375 | 11.2 | 18.61 | 26.85 | 0.1957 | 0.01900 |
| | | | | | 3500 | 11.4 | 19.05 | 27.75 | 0.1991 | 0.01900 |
| | | | | 215 50R 17 | 2875 | 10.8 | 16.50 | 23.61 | 0.1973 | 0.01894 |
| | | | | | 3000 | 10.9 | 16.96 | 24.60 | 0.2017 | 0.01895 |
| | | | | | 3250 | 11.3 | 17.83 | 26.60 | 0.2105 | 0.01897 |
| | | | | | 3375 | 11.4 | 18.25 | 27.59 | 0.2149 | 0.01898 |
| | | | | | 3500 | 11.6 | 18.66 | 28.58 | 0.2193 | 0.01898 |
| | | | | 235 40R 18 | 2875 | 10.9 | 16.29 | 25.45 | 0.2057 | 0.01846 |
| | | | | | 3000 | 11.1 | 16.70 | 26.64 | 0.2109 | 0.01845 |
| | | | | | 3250 | 11.5 | 17.50 | 29.01 | 0.2214 | 0.01842 |
| | | | | | 3375 | 11.7 | 17.88 | 30.20 | 0.2267 | 0.01840 |
| | | | | | 3500 | 11.9 | 18.24 | 31.40 | 0.2319 | 0.01839 |
| Non AGS 5DR | All | Manual | FWD | 195 65R 15 | 2875 | 10.9 | 16.34 | 22.43 | 0.2025 | 0.01964 |
| | | | | | 3000 | 11.0 | 16.81 | 23.38 | 0.2071 | 0.01963 |
| | | | | | 3250 | 11.3 | 17.72 | 25.28 | 0.2161 | 0.01961 |
| | | | | | 3375 | 11.5 | 18.15 | 26.22 | 0.2207 | 0.01961 |
| | | | | | 3500 | 11.7 | 18.57 | 27.17 | 0.2252 | 0.01960 |
| | | | | 215 55R 16 | 2875 | 11.0 | 16.20 | 23.23 | 0.1800 | 0.02005 |
| | | | | | 3000 | 11.1 | 16.68 | 24.14 | 0.1834 | 0.02006 |
| | | | | | 3250 | 11.4 | 17.60 | 25.97 | 0.1902 | 0.02008 |
| | | | | | 3375 | 11.6 | 18.04 | 26.87 | 0.1936 | 0.02009 |
| | | | | | 3500 | 11.7 | 18.48 | 27.78 | 0.1969 | 0.02010 |
| | | | | 215 50R 17 | 2875 | 11.1 | 15.98 | 23.64 | 0.1952 | 0.02003 |
| | | | | | 3000 | 11.3 | 16.43 | 24.63 | 0.1996 | 0.02004 |
| | | | | | 3250 | 11.6 | 17.29 | 26.62 | 0.2084 | 0.02006 |
| | | | | | 3375 | 11.8 | 17.70 | 27.62 | 0.2128 | 0.02007 |
| | | | | | 3500 | 12.0 | 18.11 | 28.61 | 0.2172 | 0.02007 |
| | | | | 235 40R 18 | 2875 | 11.3 | 15.78 | 25.48 | 0.2036 | 0.01955 |
| | | | | | 3000 | 11.5 | 16.19 | 26.66 | 0.2088 | 0.01954 |
| | | | | | 3250 | 11.8 | 16.98 | 29.04 | 0.2193 | 0.01951 |
| | | | | | 3375 | 12.0 | 17.35 | 30.23 | 0.2245 | 0.01950 |
| | | | | | 3500 | 12.2 | 17.71 | 31.43 | 0.2298 | 0.01948 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Focus*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Focus TRLHP Chart_1 | 6/28/2011 | 2013 Focus Non AGS All Config ι | 43 | Carryover from 2012 |
| | | 2013 Focus Historical TRLHP Non AGS New Track1.xls | | |
| 2013 Focus TRLHP Chart_1 | 7/11/2011 | 2013 Focus Non AGS All Config ι | 43 | Added 3500 ETW for ST |
| | | 2013 Focus Historical TRLHP Nc | 43 | |

| Vehicle Description | | | | | | | | Track Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| Non AGS 4DR | All | Dps6 | FWD | 195 65R 15 | 2875 | 10.5 | 16.86 | 22.97 | 0.2344 | 0.01777 |
| | | | | | 3000 | 10.7 | 17.33 | 23.92 | 0.2389 | 0.01777 |
| | | | | | 3250 | 11.0 | 18.25 | 25.81 | 0.2480 | 0.01775 |
| | | | | | 3375 | 11.2 | 18.69 | 26.76 | 0.2525 | 0.01774 |
| | | | | | 3500 | 11.3 | 19.11 | 27.71 | 0.2570 | 0.01774 |
| | | | | 215 55R 16 | 2875 | 10.6 | 16.70 | 23.76 | 0.2110 | 0.01822 |
| | | | | | 3000 | 10.8 | 17.19 | 24.67 | 0.2144 | 0.01823 |
| | | | | | 3250 | 11.1 | 18.13 | 26.50 | 0.2212 | 0.01824 |
| | | | | | 3375 | 11.2 | 18.58 | 27.40 | 0.2246 | 0.01825 |
| | | | | | 3500 | 11.4 | 19.01 | 28.31 | 0.2280 | 0.01826 |
| | | | | 215 50R 17 | 2875 | 10.8 | 16.47 | 24.16 | 0.2259 | 0.01821 |
| | | | | | 3000 | 11.0 | 16.92 | 25.16 | 0.2303 | 0.01822 |
| | | | | | 3250 | 11.3 | 17.79 | 27.15 | 0.2391 | 0.01824 |
| | | | | | 3375 | 11.5 | 18.21 | 28.14 | 0.2435 | 0.01825 |
| | | | | | 3500 | 11.6 | 18.61 | 29.14 | 0.2479 | 0.01826 |
| | | | | 235 40R 18 | 2875 | 10.9 | 16.25 | 26.01 | 0.2344 | 0.01773 |
| | | | | | 3000 | 11.1 | 16.67 | 27.19 | 0.2397 | 0.01771 |
| | | | | | 3250 | 11.5 | 17.47 | 29.57 | 0.2501 | 0.01768 |
| | | | | | 3375 | 11.7 | 17.84 | 30.76 | 0.2554 | 0.01767 |
| | | | | | 3500 | 11.9 | 18.20 | 31.96 | 0.2607 | 0.01766 |
| Non AGS 5DR | All | Dps6 | FWD | 195 65R 15 | 2875 | 10.9 | 16.31 | 22.99 | 0.2322 | 0.01887 |
| | | | | | 3000 | 11.1 | 16.78 | 23.94 | 0.2368 | 0.01886 |
| | | | | | 3250 | 11.4 | 17.69 | 25.84 | 0.2458 | 0.01884 |
| | | | | | 3375 | 11.5 | 18.12 | 26.79 | 0.2504 | 0.01883 |
| | | | | | 3500 | 11.7 | 18.54 | 27.74 | 0.2549 | 0.01883 |
| | | | | 215 55R 16 | 2875 | 11.0 | 16.17 | 23.78 | 0.2089 | 0.01931 |
| | | | | | 3000 | 11.1 | 16.65 | 24.70 | 0.2123 | 0.01932 |
| | | | | | 3250 | 11.4 | 17.57 | 26.52 | 0.2191 | 0.01934 |
| | | | | | 3375 | 11.6 | 18.01 | 27.43 | 0.2225 | 0.01934 |
| | | | | | 3500 | 11.7 | 18.44 | 28.34 | 0.2259 | 0.01935 |
| | | | | 215 50R 17 | 2875 | 11.2 | 15.95 | 24.19 | 0.2237 | 0.01931 |
| | | | | | 3000 | 11.3 | 16.40 | 25.19 | 0.2281 | 0.01931 |
| | | | | | 3250 | 11.6 | 17.26 | 27.18 | 0.2369 | 0.01933 |
| | | | | | 3375 | 11.8 | 17.67 | 28.17 | 0.2413 | 0.01934 |
| | | | | | 3500 | 12.0 | 18.07 | 29.17 | 0.2457 | 0.01935 |
| | | | | 235 40R 18 | 2875 | 11.3 | 15.74 | 26.04 | 0.2323 | 0.01882 |
| | | | | | 3000 | 11.5 | 16.16 | 27.22 | 0.2375 | 0.01880 |
| | | | | | 3250 | 11.9 | 16.94 | 29.59 | 0.2480 | 0.01878 |
| | | | | | 3375 | 12.0 | 17.32 | 30.79 | 0.2533 | 0.01876 |
| | | | | | 3500 | 12.2 | 17.68 | 31.98 | 0.2585 | 0.01875 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 Focus BEV*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2012 BEV TRLHP Cl | 9/8/2011 | 2012 BEV New Track rdm1 V43 corrJJW .31 | 43 | Results based on new track surface<br>0.315 Cd. 24.43 FA - Target Aero Used<br>38/38 psi new program tire press<br>Walked from Green 7.26 SRC to 6.9 SRC |
| 2013 BEV TRLHP Cl | 5/21/2012 | 2012 BEV New Track rdm1 V43 corrJJW .31 | 43 | Carryover from 2012 |

| Vehicle Description | | | | | | | | Track Coefficients 3 Term coefs | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| BEV | NA | BEV | FWD | P 225 50R 17 | 3875 | 11.8 | 20.26 | 23.05 | 0.3647 | 0.01897 |
| | | | | | 4000 | 11.9 | 20.71 | 23.78 | 0.3686 | 0.01896 |
| | | | | | 4250 | 12.2 | 21.55 | 25.25 | 0.3765 | 0.01896 |

# ROADLOAD CERTIFICATION SPECIFICATIONS *2013 CD4 FWD*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 FWD CD4 V8 | 9/5/2012 | CD391_533 FWD v45.xlsm | 45.0 | New Tieback<br>Engine and AGS specific bodies<br>Wind tunnel correction included<br>S/S tire pressure 36psi<br>18" added to 2.5 no ags<br>HEV tire added to S/S |

| Vehicle Description | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 3-Term | | 3 Term coefs | | |
| Body | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| CD391 AGS 1.6 | B6 | FWD | P 215 60R 16 GY | 3625 | 9.8 | 22.86 | 20.95 | 0.2529 | 0.01598 |
| | | | | 3750 | 9.9 | 23.41 | 21.64 | 0.2545 | 0.01598 |
| | | | | 3875 | 10.0 | 23.94 | 22.33 | 0.2560 | 0.01598 |
| | | | | 4000 | 10.1 | 24.47 | 23.01 | 0.2575 | 0.01598 |
| | | | P 235 50R 17 Mi | 3625 | 9.4 | 23.76 | 19.17 | 0.2341 | 0.01597 |
| | | | | 3750 | 9.5 | 24.32 | 19.86 | 0.2351 | 0.01597 |
| | | | | 3875 | 9.6 | 24.87 | 20.56 | 0.2361 | 0.01597 |
| | | | | 4000 | 9.7 | 25.41 | 21.26 | 0.2371 | 0.01596 |
| | | | P 235 45R 18 GY | 3625 | 10.0 | 22.32 | 22.96 | 0.2412 | 0.01612 |
| | | | | 3750 | 10.2 | 22.82 | 23.79 | 0.2425 | 0.01613 |
| | | | | 3875 | 10.3 | 23.30 | 24.62 | 0.2438 | 0.01613 |
| | | | | 4000 | 10.4 | 23.77 | 25.45 | 0.2451 | 0.01613 |
| | | | P 235 40R 19 Co | 3625 | 10.1 | 22.14 | 23.61 | 0.2363 | 0.01620 |
| | | | | 3750 | 10.2 | 22.65 | 24.39 | 0.2373 | 0.01621 |
| | | | | 3875 | 10.3 | 23.15 | 25.17 | 0.2383 | 0.01621 |
| | | | | 4000 | 10.5 | 23.64 | 25.95 | 0.2393 | 0.01622 |
| CD391 AGS 1.6 | 6F35 | FWD | P 215 60R 16 GY | 3625 | 10.8 | 20.81 | 20.44 | 0.5432 | 0.01328 |
| | | | | 3750 | 10.9 | 21.32 | 21.13 | 0.5447 | 0.01327 |
| | | | | 3875 | 11.0 | 21.83 | 21.81 | 0.5463 | 0.01327 |
| | | | | 4000 | 11.1 | 22.33 | 22.50 | 0.5478 | 0.01327 |
| | | | P 235 50R 17 Mi | 3625 | 10.4 | 21.55 | 18.65 | 0.5223 | 0.01330 |
| | | | | 3750 | 10.5 | 22.09 | 19.35 | 0.5233 | 0.01329 |
| | | | | 3875 | 10.6 | 22.61 | 20.04 | 0.5243 | 0.01329 |
| | | | | 4000 | 10.7 | 23.12 | 20.74 | 0.5253 | 0.01329 |
| | | | P 235 45R 18 GY | 3625 | 11.0 | 20.37 | 22.44 | 0.5279 | 0.01347 |
| | | | | 3750 | 11.1 | 20.85 | 23.27 | 0.5291 | 0.01347 |
| | | | | 3875 | 11.2 | 21.31 | 24.10 | 0.5304 | 0.01347 |
| | | | | 4000 | 11.4 | 21.76 | 24.94 | 0.5317 | 0.01348 |
| | | | P 235 40R 19 Co | 3625 | 11.1 | 20.23 | 23.10 | 0.5214 | 0.01357 |
| | | | | 3750 | 11.2 | 20.71 | 23.88 | 0.5224 | 0.01358 |
| | | | | 3875 | 11.3 | 21.19 | 24.65 | 0.5234 | 0.01358 |
| | | | | 4000 | 11.4 | 21.66 | 25.43 | 0.5244 | 0.01358 |
| CD391 AGS 1.6 S/S | 6F35 | FWD | P 235 50R 17 Mi | 3625 | 10.2 | 21.98 | 17.74 | 0.5198 | 0.01311 |
| | | | 36 psi | 3750 | 10.3 | 22.53 | 18.39 | 0.5208 | 0.01311 |
| | | | | 3875 | 10.4 | 23.07 | 19.05 | 0.5217 | 0.01311 |
| | | | | 4000 | 10.5 | 23.60 | 19.72 | 0.5227 | 0.01311 |
| | | | P 225 50R 17 Mi | 3625 | 9.9 | 22.57 | 16.36 | 0.5341 | 0.01257 |
| | | | "HEV tire" | 3750 | 10.0 | 23.15 | 16.96 | 0.5353 | 0.01257 |
| | | | | 3875 | 10.1 | 23.71 | 17.55 | 0.5365 | 0.01258 |
| | | | | 4000 | 10.2 | 24.26 | 18.14 | 0.5376 | 0.01258 |
| CD391 AGS 2.0 / 2.5 | 6F35 | FWD | P 215 60R 16 GY | 3625 | 10.9 | 20.51 | 20.40 | 0.5459 | 0.01371 |
| | | | | 3750 | 11.0 | 21.02 | 21.09 | 0.5474 | 0.01371 |
| | | | | 3875 | 11.1 | 21.52 | 21.78 | 0.5490 | 0.01371 |
| | | | | 4000 | 11.2 | 22.01 | 22.47 | 0.5505 | 0.01370 |
| | | | P 235 50R 17 Mi | 3625 | 10.5 | 21.31 | 18.37 | 0.5246 | 0.01373 |
| | | | 2.5 only | 3750 | 10.6 | 21.84 | 19.05 | 0.5256 | 0.01373 |
| | | | 33psi | 3875 | 10.7 | 22.36 | 19.74 | 0.5266 | 0.01372 |
| | | | | 4000 | 10.8 | 22.87 | 20.43 | 0.5276 | 0.01372 |
| | | | P 235 45R 18 GY | 3625 | 11.2 | 20.09 | 22.41 | 0.5305 | 0.01390 |
| | | | | 3750 | 11.3 | 20.56 | 23.24 | 0.5318 | 0.01390 |
| | | | | 3875 | 11.4 | 21.02 | 24.07 | 0.5331 | 0.01391 |
| | | | | 4000 | 11.5 | 21.46 | 24.90 | 0.5344 | 0.01391 |
| | | | P 235 40R 19 Co | 3625 | 11.2 | 19.95 | 23.06 | 0.5241 | 0.01400 |
| | | | | 3750 | 11.3 | 20.43 | 23.84 | 0.5251 | 0.01401 |
| | | | | 3875 | 11.5 | 20.90 | 24.62 | 0.5261 | 0.01401 |
| | | | | 4000 | 11.6 | 21.36 | 25.40 | 0.5271 | 0.01402 |

# ROADLOAD CERTIFICATION SPECIFICATIONS *2013 CD4 FWD*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 FWD CD4 V8 | 9/5/2012 | CD391_533 FWD v45.xlsm | 45.0 | New Tieback<br>Engine and AGS specific bodies<br>Wind tunnel correction included<br>S/S tire pressure 36psi<br>18" added to 2.5 no ags<br>HEV tire added to S/S |

| Vehicle Description | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 3-Term | | 3 Term coefs | | |
| Body | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| CD391 1.6 NO AGS | B6 | FWD | P 215 60R 16 GY | 3625 | 10.6 | 21.21 | 20.78 | 0.2660 | 0.01809 |
| | | | | 3750 | 10.7 | 21.74 | 21.47 | 0.2675 | 0.01809 |
| | | | | 3875 | 10.8 | 22.25 | 22.16 | 0.2690 | 0.01808 |
| | | | | 4000 | 10.9 | 22.75 | 22.85 | 0.2706 | 0.01808 |
| | | | P 235 50R 17 Mi | 3625 | 10.2 | 21.98 | 19.00 | 0.2471 | 0.01808 |
| | | | | 3750 | 10.3 | 22.52 | 19.69 | 0.2481 | 0.01807 |
| | | | | 3875 | 10.4 | 23.05 | 20.39 | 0.2491 | 0.01807 |
| | | | | 4000 | 10.5 | 23.57 | 21.09 | 0.2501 | 0.01807 |
| | | | P 235 45R 18 GY | 3625 | 10.8 | 20.75 | 22.79 | 0.2543 | 0.01823 |
| | | | | 3750 | 10.9 | 21.22 | 23.62 | 0.2555 | 0.01823 |
| | | | | 3875 | 11.0 | 21.69 | 24.45 | 0.2568 | 0.01823 |
| | | | | 4000 | 11.2 | 22.15 | 25.28 | 0.2581 | 0.01824 |
| | | | P 235 40R 19 Co | 3625 | 10.9 | 20.59 | 23.44 | 0.2493 | 0.01831 |
| | | | | 3750 | 11.0 | 21.08 | 24.22 | 0.2504 | 0.01831 |
| | | | | 3875 | 11.1 | 21.56 | 25.00 | 0.2514 | 0.01832 |
| | | | | 4000 | 11.2 | 22.03 | 25.78 | 0.2524 | 0.01832 |
| | | | P 235 45R 18 S/D | 3625 | 11.2 | 20.00 | 26.17 | 0.2559 | 0.01804 |
| | | | | 3750 | 11.3 | 20.48 | 26.97 | 0.2571 | 0.01804 |
| | | | | 3875 | 11.4 | 20.95 | 27.77 | 0.2582 | 0.01804 |
| | | | | 4000 | 11.5 | 21.41 | 28.57 | 0.2593 | 0.01803 |
| CD391 1.6 NO AGS | 6F35 | FWD | P 215 60R 16 GY | 3625 | 11.5 | 19.43 | 20.27 | 0.5562 | 0.01538 |
| | | | | 3750 | 11.6 | 19.93 | 20.96 | 0.5578 | 0.01538 |
| | | | | 3875 | 11.7 | 20.41 | 21.65 | 0.5593 | 0.01538 |
| | | | | 4000 | 11.8 | 20.89 | 22.33 | 0.5608 | 0.01538 |
| | | | P 235 50R 17 Mi | 3625 | 11.2 | 20.08 | 18.48 | 0.5354 | 0.01540 |
| | | | | 3750 | 11.3 | 20.59 | 19.18 | 0.5364 | 0.01540 |
| | | | | 3875 | 11.4 | 21.09 | 19.87 | 0.5374 | 0.01540 |
| | | | | 4000 | 11.5 | 21.58 | 20.57 | 0.5384 | 0.01539 |
| | | | P 235 45R 18 GY | 3625 | 11.8 | 19.05 | 22.27 | 0.5409 | 0.01557 |
| | | | | 3750 | 11.9 | 19.51 | 23.10 | 0.5422 | 0.01558 |
| | | | | 3875 | 12.0 | 19.95 | 23.93 | 0.5435 | 0.01558 |
| | | | | 4000 | 12.1 | 20.39 | 24.77 | 0.5448 | 0.01558 |
| | | | P 235 40R 19 Co | 3625 | 11.8 | 18.92 | 22.93 | 0.5344 | 0.01568 |
| | | | | 3750 | 12.0 | 19.39 | 23.71 | 0.5354 | 0.01568 |
| | | | | 3875 | 12.1 | 19.85 | 24.48 | 0.5364 | 0.01569 |
| | | | | 4000 | 12.2 | 20.30 | 25.26 | 0.5375 | 0.01569 |
| | | | P 235 45R 18 S/D | 3625 | 12.2 | 18.42 | 25.65 | 0.5426 | 0.01539 |
| | | | | 3750 | 12.3 | 18.88 | 26.46 | 0.5437 | 0.01539 |
| | | | | 3875 | 12.4 | 19.33 | 27.26 | 0.5448 | 0.01538 |
| | | | | 4000 | 12.5 | 19.77 | 28.06 | 0.5459 | 0.01538 |
| CD391 2.0 NO AGS | 6F35 | FWD | P 215 60R 16 GY | 3625 | 11.7 | 19.21 | 20.24 | 0.5585 | 0.01575 |
| | | | | 3750 | 11.8 | 19.70 | 20.93 | 0.5601 | 0.01575 |
| | | | | 3875 | 11.9 | 20.18 | 21.62 | 0.5616 | 0.01575 |
| | | | | 4000 | 12.0 | 20.65 | 22.30 | 0.5632 | 0.01575 |
| | | | P 235 50R 17 Mi | 3625 | 11.3 | 19.84 | 18.45 | 0.5377 | 0.01577 |
| | | | | 3750 | 11.4 | 20.35 | 19.15 | 0.5387 | 0.01577 |
| | | | | 3875 | 11.5 | 20.85 | 19.84 | 0.5397 | 0.01577 |
| | | | | 4000 | 11.6 | 21.33 | 20.54 | 0.5407 | 0.01576 |
| | | | P 235 45R 18 GY | 3625 | 11.9 | 18.84 | 22.24 | 0.5432 | 0.01595 |
| | | | | 3750 | 12.0 | 19.29 | 23.07 | 0.5445 | 0.01595 |
| | | | | 3875 | 12.1 | 19.73 | 23.90 | 0.5458 | 0.01595 |
| | | | | 4000 | 12.3 | 20.17 | 24.74 | 0.5471 | 0.01595 |
| | | | P 235 40R 19 Co | 3625 | 12.0 | 18.71 | 22.90 | 0.5367 | 0.01605 |
| | | | | 3750 | 12.1 | 19.18 | 23.68 | 0.5377 | 0.01605 |
| | | | | 4000 | 12.3 | 20.08 | 25.23 | 0.5398 | 0.01606 |
| | | | P 235 45R 18 S/D | 3625 | 12.3 | 18.22 | 25.62 | 0.5449 | 0.01576 |
| | | | | 3750 | 12.4 | 18.67 | 26.43 | 0.5460 | 0.01576 |
| | | | | 3875 | 12.5 | 19.12 | 27.23 | 0.5471 | 0.01575 |
| | | | | 4000 | 12.6 | 19.56 | 28.03 | 0.5482 | 0.01575 |

# ROADLOAD CERTIFICATION SPECIFICATIONS *2013 CD4 FWD*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 FWD CD4 V8 | 9/5/2012 | CD391_533 FWD v45.xlsm | 45.0 | New Tieback<br>Engine and AGS specific bodies<br>Wind tunnel correction included<br>S/S tire pressure 36psi<br>18" added to 2.5 no ags<br>HEV tire added to S/S |

| Vehicle Description | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 3-Term | | 3 Term coefs | | |
| Body | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| CD391 2.5 NO AGS | 6F35 | FWD | P 215 60R 16 GY | 3625 | 11.4 | 19.70 | 20.31 | 0.5536 | 0.01495 |
| | | | | 3750 | 11.5 | 20.20 | 20.99 | 0.5551 | 0.01495 |
| | | | | 3875 | 11.6 | 20.69 | 21.68 | 0.5566 | 0.01495 |
| | | | | 4000 | 11.7 | 21.17 | 22.37 | 0.5582 | 0.01494 |
| | | | P 235 50R 17 Mi | 3625 | 11.0 | 20.37 | 18.52 | 0.5327 | 0.01497 |
| | | | | 3750 | 11.1 | 20.88 | 19.21 | 0.5337 | 0.01496 |
| | | | | 3875 | 11.2 | 21.39 | 19.91 | 0.5347 | 0.01496 |
| | | | | 4000 | 11.3 | 21.88 | 20.61 | 0.5357 | 0.01496 |
| | | | P 235 45R 18 GY | 3625 | 11.6 | 19.31 | 22.31 | 0.5382 | 0.01514 |
| | | | | 3750 | 11.7 | 19.77 | 23.14 | 0.5395 | 0.01514 |
| | | | | 3875 | 11.8 | 20.22 | 23.97 | 0.5408 | 0.01515 |
| | | | | 4000 | 12.0 | 20.66 | 24.80 | 0.5421 | 0.01515 |
| | | | P 235 45R 18 S/M | 3625 | 12.0 | 18.66 | 25.69 | 0.5399 | 0.01496 |
| | | | | 3750 | 12.1 | 19.12 | 26.49 | 0.5410 | 0.01495 |
| | | | | 3875 | 12.2 | 19.57 | 27.29 | 0.5421 | 0.01495 |
| | | | | 4000 | 12.3 | 20.02 | 28.09 | 0.5433 | 0.01495 |
| CD533_2.0 NO AGS | 6F35 | FWD | P 245 45R 18 A/S | 3875 | 11.7 | 20.40 | 26.35 | 0.4935 | 0.01481 |
| | | | | 4000 | 11.9 | 20.83 | 27.29 | 0.4936 | 0.01481 |
| | | | | 4250 | 12.1 | 21.66 | 29.18 | 0.4938 | 0.01482 |
| | | | | 4500 | 12.4 | 22.46 | 31.08 | 0.4939 | 0.01484 |
| | | | P 245 40R 19 A/S | 3875 | 11.5 | 20.85 | 24.49 | 0.4936 | 0.01480 |
| | | | | 4000 | 11.6 | 21.31 | 25.35 | 0.4937 | 0.01480 |
| | | | | 4250 | 11.8 | 22.19 | 27.06 | 0.4939 | 0.01481 |
| | | | | 4500 | 12.1 | 23.04 | 28.78 | 0.4941 | 0.01482 |
| | | | P 245 40R 18 S/D | 3875 | 12.2 | 19.56 | 28.55 | 0.5336 | 0.01464 |
| | | | | 4000 | 12.4 | 19.98 | 29.44 | 0.5350 | 0.01464 |
| | | | | 4250 | 12.6 | 20.79 | 31.24 | 0.5377 | 0.01464 |
| | | | | 4500 | 12.9 | 21.58 | 33.03 | 0.5404 | 0.01464 |
| | | | P 245 40R 19 S/D | 3875 | 11.8 | 20.36 | 27.19 | 0.4733 | 0.01495 |
| | | | | 4000 | 11.9 | 20.79 | 28.14 | 0.4727 | 0.01496 |
| | | | | 4250 | 12.1 | 21.63 | 30.05 | 0.4714 | 0.01498 |
| | | | | 4500 | 12.4 | 22.43 | 31.96 | 0.4701 | 0.01500 |
| CD533_3.7 AGS | 6F50 | FWD | P 245 45R 18 A/S | 3875 | 11.4 | 20.94 | 31.65 | 0.2415 | 0.01681 |
| | | | | 4000 | 11.6 | 21.38 | 32.59 | 0.2416 | 0.01682 |
| | | | | 4250 | 11.8 | 22.22 | 34.48 | 0.2417 | 0.01683 |
| | | | | 4500 | 12.1 | 23.02 | 36.39 | 0.2419 | 0.01684 |
| | | | P 245 40R 19 A/S | 3875 | 11.2 | 21.41 | 29.79 | 0.2422 | 0.01679 |
| | | | | 4000 | 11.3 | 21.88 | 30.65 | 0.2423 | 0.01680 |
| | | | | 4250 | 11.5 | 22.77 | 32.36 | 0.2425 | 0.01681 |
| | | | | 4500 | 11.8 | 23.63 | 34.08 | 0.2427 | 0.01682 |
| | | | P 245 40R 18 S/D | 3875 | 11.9 | 20.05 | 33.85 | 0.2816 | 0.01665 |
| | | | | 4000 | 12.1 | 20.48 | 34.75 | 0.2830 | 0.01665 |
| | | | | 4250 | 12.3 | 21.30 | 36.54 | 0.2857 | 0.01665 |
| | | | | 4500 | 12.6 | 22.09 | 38.33 | 0.2884 | 0.01664 |
| | | | P 245 40R 19 S/D | 3875 | 11.5 | 20.89 | 32.49 | 0.2219 | 0.01695 |
| | | | | 4000 | 11.6 | 21.33 | 33.44 | 0.2213 | 0.01696 |
| | | | | 4250 | 11.8 | 22.18 | 35.35 | 0.2200 | 0.01698 |
| | | | | 4500 | 12.1 | 22.99 | 37.26 | 0.2187 | 0.01700 |

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# ROADLOAD CERTIFICATION SPECIFICATIONS *2013 CD4 AWD*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 CD4 AWD | 7/31/2012 | cd4 awd rdm v45 | 45.0 | New Tieback<br>S/D, S/M indicates "summer" tire<br>Updated aero - wind tunnel correlation<br>Summer tire added to no ags 2.0 |

| Vehicle Description | | | | | | 3-Term | | Single Roll Settings | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 3 Term coefs | | |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| CD391 AGS | 2.0 GTDI | 6F35 | AWD | P 215 60R 16 GY | 3625 | 11.9 | 18.77 | 22.27 | 0.5911 | 0.01510 |
| | | | | | 3750 | 12.0 | 19.25 | 22.97 | 0.5927 | 0.01510 |
| | | | | | 3875 | 12.1 | 19.72 | 23.66 | 0.5943 | 0.01510 |
| | | | | | 4000 | 12.3 | 20.19 | 24.36 | 0.5959 | 0.01509 |
| | | | | P 235 50R 17 Mi | 3625 | 11.6 | 19.39 | 20.46 | 0.5696 | 0.01510 |
| | | | | | 3750 | 11.7 | 19.89 | 21.16 | 0.5707 | 0.01510 |
| | | | | | 3875 | 11.8 | 20.38 | 21.87 | 0.5717 | 0.01510 |
| | | | | | 4000 | 11.9 | 20.86 | 22.57 | 0.5728 | 0.01510 |
| | | | | P 235 45R 18 GY | 3625 | 12.2 | 18.43 | 24.29 | 0.5751 | 0.01527 |
| | | | | | 3750 | 12.3 | 18.87 | 25.13 | 0.5764 | 0.01527 |
| | | | | | 3875 | 12.4 | 19.31 | 25.97 | 0.5778 | 0.01527 |
| | | | | | 4000 | 12.5 | 19.74 | 26.81 | 0.5791 | 0.01528 |
| | | | | P 235 40R 19 Conti | 3625 | 12.2 | 18.32 | 24.95 | 0.5683 | 0.01536 |
| | | | | | 3750 | 12.3 | 18.77 | 25.73 | 0.5694 | 0.01537 |
| | | | | | 3875 | 12.5 | 19.22 | 26.52 | 0.5704 | 0.01537 |
| | | | | | 4000 | 12.6 | 19.66 | 27.31 | 0.5714 | 0.01538 |
| CD391 NO AGS | 2.0 GTDI | 6F35 | AWD | P 215 60R 16 GY | 3625 | 12.7 | 17.66 | 22.11 | 0.6038 | 0.01716 |
| | | | | | 3750 | 12.8 | 18.13 | 22.80 | 0.6054 | 0.01716 |
| | | | | | 3875 | 12.9 | 18.58 | 23.50 | 0.6070 | 0.01716 |
| | | | | | 4000 | 13.0 | 19.03 | 24.19 | 0.6085 | 0.01715 |
| | | | | P 235 50R 17 Mi | 3625 | 12.3 | 18.22 | 20.30 | 0.5823 | 0.01717 |
| | | | | | 3750 | 12.4 | 18.69 | 21.00 | 0.5833 | 0.01716 |
| | | | | | 3875 | 12.5 | 19.16 | 21.70 | 0.5844 | 0.01716 |
| | | | | | 4000 | 12.6 | 19.62 | 22.41 | 0.5854 | 0.01716 |
| | | | | P 235 45R 18 GY | 3625 | 12.9 | 17.36 | 24.12 | 0.5878 | 0.01733 |
| | | | | | 3750 | 13.0 | 17.79 | 24.96 | 0.5891 | 0.01733 |
| | | | | | 3875 | 13.2 | 18.21 | 25.80 | 0.5904 | 0.01734 |
| | | | | | 4000 | 13.3 | 18.63 | 26.65 | 0.5917 | 0.01734 |
| | | | | P 235 40R 19 Conti | 3625 | 13.0 | 17.26 | 24.78 | 0.5810 | 0.01742 |
| | | | | | 3750 | 13.1 | 17.70 | 25.57 | 0.5820 | 0.01743 |
| | | | | | 3875 | 13.2 | 18.14 | 26.36 | 0.5831 | 0.01743 |
| | | | | | 4000 | 13.3 | 18.56 | 27.14 | 0.5841 | 0.01744 |
| | | | | P 235 45R 18 S/M | 3625 | 13.3 | 16.83 | 27.54 | 0.5896 | 0.01714 |
| | | | | | 3750 | 13.4 | 17.26 | 28.35 | 0.5907 | 0.01714 |
| | | | | | 3875 | 13.5 | 17.68 | 29.16 | 0.5919 | 0.01714 |
| | | | | | 4000 | 13.7 | 18.10 | 29.97 | 0.5931 | 0.01713 |
| CD533 AGS | 3.7 | 6F50 | AWD | P 245 45R 18 A/S Mi | 3875 | 12.9 | 18.50 | 27.65 | 0.7692 | 0.01238 |
| | | | | | 4000 | 13.1 | 18.91 | 28.60 | 0.7693 | 0.01239 |
| | | | | | 4250 | 13.3 | 19.70 | 30.52 | 0.7695 | 0.01240 |
| | | | | | 4500 | 13.6 | 20.45 | 32.44 | 0.7697 | 0.01241 |
| | | | | P 245 40R 19 A/S Mi | 3875 | 12.7 | 18.79 | 26.04 | 0.7741 | 0.01234 |
| | | | | | 4000 | 12.9 | 19.21 | 26.91 | 0.7745 | 0.01234 |
| | | | | | 4250 | 13.1 | 20.04 | 28.68 | 0.7752 | 0.01235 |
| | | | | | 4500 | 13.4 | 20.83 | 30.45 | 0.7758 | 0.01235 |
| | | | | P 245 40R 18 S/D | 3875 | 13.6 | 17.62 | 30.05 | 0.8552 | 0.01164 |
| | | | | | 4000 | 13.7 | 18.02 | 30.96 | 0.8564 | 0.01164 |
| | | | | | 4250 | 14.0 | 18.78 | 32.79 | 0.8590 | 0.01164 |
| | | | | | 4500 | 14.2 | 19.52 | 34.61 | 0.8615 | 0.01164 |
| | | | | P 245 40R 19 S/D | 3875 | 13.5 | 17.72 | 31.13 | 0.7918 | 0.01225 |
| | | | | | 4000 | 13.6 | 18.12 | 32.05 | 0.7926 | 0.01225 |
| | | | | | 4250 | 13.9 | 18.89 | 33.89 | 0.7943 | 0.01225 |
| | | | | | 4500 | 14.2 | 19.64 | 35.72 | 0.7960 | 0.01225 |
| CD533 NO AGS | 2.0L | 6f35 | AWD | P 245 45R 18 A/S Mi | 3875 | 12.6 | 18.97 | 28.18 | 0.5220 | 0.01616 |
| | | | | | 4000 | 12.8 | 19.39 | 29.14 | 0.5221 | 0.01616 |
| | | | | | 4250 | 13.0 | 20.18 | 31.05 | 0.5223 | 0.01618 |
| | | | | | 4500 | 13.3 | 20.95 | 32.97 | 0.5225 | 0.01619 |
| | | | | P 245 40R 19 A/S Mi | 3875 | 12.4 | 19.28 | 26.57 | 0.5276 | 0.01611 |
| | | | | | 4000 | 12.5 | 19.71 | 27.45 | 0.5280 | 0.01611 |
| | | | | | 4250 | 12.8 | 20.54 | 29.21 | 0.5286 | 0.01611 |
| | | | | | 4500 | 13.0 | 21.34 | 30.99 | 0.5293 | 0.01612 |
| | | | | P 245 40R 18 S/D | 3875 | 13.3 | 18.05 | 30.57 | 0.5896 | 0.01578 |
| | | | | | 4000 | 13.4 | 18.45 | 31.49 | 0.5909 | 0.01578 |
| | | | | | 4250 | 13.7 | 19.23 | 33.31 | 0.5935 | 0.01578 |
| | | | | | 4500 | 13.9 | 19.98 | 35.13 | 0.5960 | 0.01578 |
| | | | | P 245 40R 19 S/D | 3875 | 13.2 | 18.15 | 31.66 | 0.5453 | 0.01602 |
| | | | | | 4000 | 13.3 | 18.55 | 32.58 | 0.5461 | 0.01602 |
| | | | | | 4250 | 13.6 | 19.34 | 34.42 | 0.5478 | 0.01602 |
| | | | | | 4500 | 13.8 | 20.09 | 36.26 | 0.5495 | 0.01602 |

# ROADLOAD CERTIFICATION SPECIFICATIONS *2013 HEV CD4X*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 CD4 HEV V2 | 9/18/2012 | CD391 C344 CD533 HEV v44 M1.xls | 45 | 17" at 35psi for 391, 38 psi for 344<br>New Tieback process, updated 19"AS tire<br>Aero values revised to global standard<br>2.91 added to 533 |

| Vehicle Description | | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | 3 Term coefs | | |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| CD391 P-HEV | 2.0 | HF35 2.91 | FWD | P 225 50R 17 | 4000 | 10.4 | 23.89 | 22.71 | 0.36464 | 0.01468 |
| | | | | | 4250 | 10.5 | 24.95 | 23.9 | 0.36699 | 0.01469 |
| | | | | | 4500 | 10.7 | 25.98 | 25.1 | 0.36935 | 0.01470 |
| | | | | P 235 45R 18 AS | 4000 | 11.2 | 21.99 | 29.48 | 0.35986 | 0.01473 |
| | | | | | 4250 | 11.5 | 22.87 | 31.16 | 0.36244 | 0.01473 |
| | | | | | 4500 | 11.7 | 23.71 | 32.83 | 0.36504 | 0.01474 |
| CD391 F-HEV | 2.0 | HF35 2.57 | FWD | P 225 50R 17 | 4000 | 10.1 | 24.50 | 22.68 | 0.34024 | 0.01441 |
| | | | | | 4250 | 10.3 | 25.58 | 23.88 | 0.34258 | 0.01442 |
| | | | | | 4500 | 10.5 | 26.62 | 25.08 | 0.34494 | 0.01442 |
| | | | | P 235 45R 18 AS | 4000 | 11.0 | 22.49 | 29.46 | 0.33635 | 0.01446 |
| | | | | | 4250 | 11.2 | 23.37 | 31.13 | 0.33893 | 0.01447 |
| | | | | | 4500 | 11.5 | 24.22 | 32.81 | 0.34152 | 0.01448 |
| C344 P-HEV | 2.0 | HF35 2.91 | FWD | P 225 50R 17 | 4000 | 11.7 | 21.09 | 21.78 | 0.38854 | 0.01873 |
| | | | | | 4250 | 11.9 | 22.08 | 22.93 | 0.3908 | 0.01874 |
| | | | | | 4500 | 12.1 | 23.04 | 24.09 | 0.39308 | 0.01874 |
| C344 F-HEV | 2.0 | HF35 2.57 | FWD | P 225 50R 17 | 4000 | 11.5 | 21.47 | 21.76 | 0.36496 | 0.01859 |
| | | | | | 4250 | 11.7 | 22.47 | 22.9 | 0.36723 | 0.01859 |
| | | | | | 4500 | 11.9 | 23.45 | 24.06 | 0.36951 | 0.01860 |
| CD533 F-HEV | 2.0 | HF35 2.57 | FWD | P 245 45R 18 AS | 4000 | 11.4 | 21.71 | 31.78 | 0.30115 | 0.01543 |
| | | | | | 4250 | 11.6 | 22.55 | 33.67 | 0.30129 | 0.01544 |
| | | | | | 4500 | 11.9 | 23.36 | 35.57 | 0.30143 | 0.01545 |
| | | | | P 245 40R 19 AS | 4000 | 11.1 | 22.22 | 29.84 | 0.30169 | 0.01541 |
| | | | | | 4250 | 11.4 | 23.12 | 31.55 | 0.3019 | 0.01542 |
| | | | | | 4500 | 11.6 | 23.99 | 33.26 | 0.30211 | 0.01543 |
| | | | | P 245 45R 18 SD | 4000 | 11.9 | 20.81 | 33.96 | 0.3384 | 0.01527 |
| | | | | | 4250 | 12.1 | 21.64 | 35.76 | 0.34088 | 0.01527 |
| | | | | | 4500 | 12.4 | 22.44 | 37.56 | 0.34335 | 0.01527 |
| | | | | P 245 40R 19 SD | 4000 | 12.0 | 20.67 | 35.2 | 0.32529 | 0.01528 |
| | | | | | 4250 | 12.2 | 21.50 | 37.02 | 0.32691 | 0.01528 |
| | | | | | 4500 | 12.5 | 22.30 | 38.84 | 0.32853 | 0.01528 |
| | 2.0 | HF35 2.91 | FWD | P 245 45R 18 AS | 4000 | 11.6 | 21.26 | 31.8 | 0.324 | 0.01568 |
| | | | | | 4250 | 11.9 | 22.10 | 33.69 | 0.3242 | 0.01569 |
| | | | | | 4500 | 12.1 | 22.90 | 35.59 | 0.3243 | 0.01570 |
| | | | | P 245 40R 19 AS | 4000 | 11.4 | 21.75 | 29.86 | 0.3245 | 0.01566 |
| | | | | | 4250 | 11.6 | 22.64 | 31.57 | 0.3247 | 0.01567 |
| | | | | | 4500 | 11.8 | 23.50 | 33.29 | 0.3249 | 0.01568 |

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## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 MKS*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 MKS TRLHP Chart_1 | 6/30/2011 | 2013 MKS FWD New Track 3.2% imp | 43 | Aero adjusted for AGS |
| | | | | .320 Cd, 2.55 M^2 FA |
| 2013 MKS TRLHP Chart_1 | 7/28/2011 | 2013 MKS FWD New Track rdm1 V43 | 43 | Full New Track Benefit |
| | | | | New 19" Mi Tire @ 9.8 SRC |
| | | | | 19" Tire Press, 34/34 psi |
| 2013 MKS TRLHP Chart_2 | 10/24/2011 | 2013 MKS FWD New Track rdm2 V43 | 43 | 19" Tire SRC Chg from |
| | | | | 9.8 to 9.2 per VEMC Engr |
| | | | | 20" Tire SRC Chg from |
| | | | | 10.6 to 9.51 per VEMC Engr |
| 2013 MKS TRLHP Chart_3 | 11/24/2011 | 2013 MKS FWD New Track rdm3 V43 | 43 | Mi 19" & Mi 20 " Tire SRC Changed |
| | | | | FWD CD Changed from .320 to .329 |
| 2013 MKS TRLHP Chart_4 | 12/7/2011 | 2013 MKS FWD New Track rdm4 V43 | 43 | Changed from .329 to .319 CD |
| 2013 MKS TRLHP Chart_4 | 12/13/2011 | 2013 MKS FWD New Track rdm4 V43 | 43 | No Changes |

| Vehicle Description | | | | | | | | 3 Term | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| MKS FWD | 3.7L | Auto | FWD | 255 45R 19 | 4250 | 12.5 | 21.00 | 19.75 | 0.6296 | 0.01707 |
| | | | | | 4500 | 12.8 | 21.72 | 21.61 | 0.6353 | 0.01709 |
| | | | | | 4750 | 13.1 | 22.41 | 23.48 | 0.6410 | 0.01711 |
| | | | | 245 45R 20 | 4250 | 12.9 | 20.38 | 24.02 | 0.5867 | 0.01734 |
| | | | | | 4500 | 13.2 | 21.08 | 26.04 | 0.5909 | 0.01736 |
| | | | | | 4750 | 13.5 | 21.75 | 28.06 | 0.5951 | 0.01737 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 MKS*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 MKS TRLHP Chart_1 | 6/30/2011 | 2013 MKS AWD New Track % Co | 43 | .346 Cd, 2.55 m^2 FA |
| 2013 MKS TRLHP Chart_1 | 7/28/2011 | 2013 MKS AWD New Track % Co | 43 | New 19" Mi Tire @ 9.8 SRC<br>19" Tire Press, 34/34 psi<br>Est. 5% improv. for New Track Surface |
| 2013 MKS TRLHP Chart_2 | 10/24/2011 | 2013 MKS AWD New Track rdm2 | 43 | 19" Tire SRC Chg from<br>9.8 to 9.2 per VEMC Engr<br>20" Tire SRC Chg from<br>10.6 to 9.51 per VEMC Engr |
| 2013 MKS TRLHP Chart_3 | 11/24/2011 | 2013 MKS AWD New Track rdm3 | 43 | Mi 19" & Mi 20 " Tire SRC Changed<br>Non GTDI AWD CD Changed<br>from .337 to .329 |
| 2013 MKS TRLHP Chart_4 | 12/7/2011 | 2013 MKS AWD New Track rdm4 | 43 | Non GTDI AWD CD Changed<br>from .329 to .319 |
| 2013 MKS TRLHP Chart_5 | 12/13/2011 | 2013 MKS AWD New Track rdm5 | 43 | Walk from coasted 2013 AWD<br>Taurus (New Track Surface) |

| Vehicle Description | | | | | | | | Track Coefficients 3 Term | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| MKS AWD | 3.7L | Auto | AWD | 255 45R 19 | 4500 | 13.7 | 20.34 | 24.42 | 0.7026 | 0.01721 |
| | | | | | 4750 | 14.0 | 21.02 | 26.29 | 0.7083 | 0.01723 |
| | | | | | 5000 | 14.3 | 21.66 | 28.17 | 0.7140 | 0.01725 |
| | | | | 245 45R 20 | 4500 | 14.0 | 19.81 | 28.81 | 0.6528 | 0.01755 |
| | | | | | 4750 | 14.3 | 20.46 | 30.83 | 0.6570 | 0.01757 |
| | | | | | 5000 | 14.6 | 21.09 | 32.85 | 0.6612 | 0.01758 |
| MKS | 3.5L_GTDI | Auto | AWD | 255 45R 19 | 4500 | 14.1 | 19.68 | 29.30 | 0.4534 | 0.02163 |
| | | | | | 4750 | 14.4 | 20.35 | 31.17 | 0.4591 | 0.02165 |
| | | | | | 5000 | 14.7 | 20.99 | 33.05 | 0.4648 | 0.02167 |
| | | | | 245 45R 20 | 4500 | 14.5 | 19.18 | 33.58 | 0.4147 | 0.02178 |
| | | | | | 4750 | 14.8 | 19.83 | 35.60 | 0.4189 | 0.02180 |
| | | | | | 5000 | 15.1 | 20.45 | 37.62 | 0.4231 | 0.02182 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Mustang*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Mustang | 9/7/2011 | 2012 Mustang trlhp v3.xls | 43.0 | Spare tire added, aero updated |

| Vehicle Description | | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | 3 Term coefs | | |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| V6 Coupe | 3.7 | Manual | RWD | P 215 65R 17 Mi | 3750 | 10.7 | 21.72 | 15.51 | 0.3930 | 0.01800 |
| | | | | | 3875 | 10.8 | 22.16 | 16.38 | 0.3951 | 0.01801 |
| | | | | | 4000 | 11.0 | 22.60 | 17.24 | 0.3972 | 0.01802 |
| | | | | | 4250 | 11.2 | 23.44 | 18.97 | 0.4015 | 0.01804 |
| | | | | P 225 60R 17 BF | 3750 | 11.9 | 19.44 | 23.72 | 0.4117 | 0.01807 |
| | | | | | 3875 | 12.1 | 19.79 | 24.88 | 0.4143 | 0.01808 |
| | | | | | 4000 | 12.3 | 20.13 | 26.04 | 0.4169 | 0.01810 |
| | | | | | 4250 | 12.6 | 20.79 | 28.36 | 0.4221 | 0.01813 |
| | | | | P 235 50R 18 Pi | 3750 | 12.3 | 18.80 | 28.46 | 0.3851 | 0.01790 |
| | | | | | 3875 | 12.5 | 19.12 | 29.86 | 0.3866 | 0.01791 |
| | | | | | 4000 | 12.7 | 19.42 | 31.26 | 0.3881 | 0.01793 |
| | | | | | 4250 | 13.1 | 20.00 | 34.06 | 0.3911 | 0.01795 |
| | | | | P 255 40ZR 19 Pi | 3750 | 12.7 | 18.18 | 31.46 | 0.4388 | 0.01687 |
| | | | | 3.31 axle only | 3875 | 12.9 | 18.51 | 32.81 | 0.4418 | 0.01685 |
| | | | | | 4000 | 13.1 | 18.82 | 34.15 | 0.4447 | 0.01683 |
| | | | | | 4250 | 13.5 | 19.43 | 36.84 | 0.4507 | 0.01679 |
| V6 Coupe | 3.7 | Automatic | RWD | P 215 65R 17 Mi | 3750 | 10.8 | 21.57 | 20.49 | 0.1739 | 0.02061 |
| | | | | | 3875 | 10.9 | 22.01 | 21.35 | 0.1760 | 0.02062 |
| | | | | | 4000 | 11.0 | 22.44 | 22.21 | 0.1781 | 0.02064 |
| | | | | | 4250 | 11.3 | 23.28 | 23.94 | 0.1824 | 0.02066 |
| | | | | P 225 60R 17 BF | 3750 | 12.0 | 19.31 | 28.76 | 0.1867 | 0.02079 |
| | | | | | 3875 | 12.2 | 19.66 | 29.92 | 0.1893 | 0.02081 |
| | | | | | 4000 | 12.4 | 20.00 | 31.08 | 0.1919 | 0.02082 |
| | | | | | 4250 | 12.7 | 20.65 | 33.40 | 0.1970 | 0.02086 |
| | | | | P 235 50R 18 Pi | 3750 | 12.4 | 18.67 | 33.58 | 0.1538 | 0.02074 |
| | | | | | 3875 | 12.6 | 18.98 | 34.97 | 0.1553 | 0.02075 |
| | | | | | 4000 | 12.8 | 19.29 | 36.37 | 0.1567 | 0.02076 |
| | | | | | 4250 | 13.2 | 19.87 | 39.17 | 0.1597 | 0.02079 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Mustang*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Mustang | 9/7/2011 | 2012 Mustang trlhp v3.xls | 43.0 | Spare tire added, aero updated |

| Vehicle Description | | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | 3 Term coefs | | |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| V6 convt. | 3.7 | Manual | RWD | P 215 65R 17 Mi | 3750 | 11.0 | 21.03 | 15.51 | 0.3930 | 0.01906 |
| | | | | | 3875 | 11.2 | 21.46 | 16.38 | 0.3951 | 0.01907 |
| | | | | | 4000 | 11.3 | 21.90 | 17.24 | 0.3972 | 0.01908 |
| | | | | | 4250 | 11.6 | 22.72 | 18.97 | 0.4015 | 0.01911 |
| | | | | P 225 60R 17 BF | 3750 | 12.3 | 18.88 | 23.72 | 0.4117 | 0.01913 |
| | | | | | 3875 | 12.5 | 19.23 | 24.88 | 0.4143 | 0.01915 |
| | | | | | 4000 | 12.6 | 19.57 | 26.04 | 0.4169 | 0.01916 |
| | | | | | 4250 | 13.0 | 20.22 | 28.36 | 0.4221 | 0.01920 |
| | | | | P 235 50R 18 Pi | 3750 | 12.7 | 18.28 | 28.46 | 0.3851 | 0.01896 |
| | | | | | 3875 | 12.9 | 18.59 | 29.86 | 0.3866 | 0.01897 |
| | | | | | 4000 | 13.1 | 18.89 | 31.26 | 0.3881 | 0.01899 |
| | | | | | 4250 | 13.5 | 19.47 | 34.06 | 0.3911 | 0.01902 |
| V6 convt. | 3.7 | Automatic | RWD | P 215 65R 17 Mi | 3750 | 11.1 | 20.88 | 20.49 | 0.1739 | 0.02167 |
| | | | | | 3875 | 11.2 | 21.32 | 21.35 | 0.1760 | 0.02169 |
| | | | | | 4000 | 11.4 | 21.75 | 22.21 | 0.1781 | 0.02170 |
| | | | | | 4250 | 11.6 | 22.58 | 23.94 | 0.1824 | 0.02172 |
| | | | | P 225 60R 17 BF | 3750 | 12.4 | 18.76 | 28.76 | 0.1867 | 0.02185 |
| | | | | | 3875 | 12.5 | 19.11 | 29.92 | 0.1893 | 0.02187 |
| | | | | | 4000 | 12.7 | 19.44 | 31.08 | 0.1919 | 0.02189 |
| | | | | | 4250 | 13.1 | 20.10 | 33.40 | 0.1970 | 0.02192 |
| | | | | P 235 50R 18 Pi | 3750 | 12.8 | 18.15 | 33.58 | 0.1538 | 0.02180 |
| | | | | | 3875 | 13.0 | 18.47 | 34.97 | 0.1553 | 0.02181 |
| | | | | | 4000 | 13.2 | 18.77 | 36.37 | 0.1567 | 0.02182 |
| | | | | | 4250 | 13.6 | 19.35 | 39.17 | 0.1597 | 0.02185 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 Mustang*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 Mustang | 9/7/2011 | 2012 Mustang trlhp v3.xls | 43.0 | Updated test results |

| Vehicle Description | | | | | | 3-Term | | Single Roll Settings<br>3 Term coefs | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| V8 Coupe | 5.0 | Manual | RWD | P 235 50R 18 Pi | 3750 | 12.6 | 18.36 | 27.60 | 0.4239 | 0.01837 |
| | | | | | 3875 | 12.8 | 18.67 | 28.99 | 0.4254 | 0.01839 |
| | | | | | 4000 | 13.0 | 18.97 | 30.39 | 0.4269 | 0.01840 |
| | | | | | 4250 | 13.4 | 19.55 | 33.19 | 0.4299 | 0.01843 |
| | | | | P 245 45R 19 Pi | 3750 | 13.1 | 17.75 | 31.54 | 0.3856 | 0.01884 |
| | | | | | 3875 | 13.3 | 18.04 | 33.08 | 0.3860 | 0.01887 |
| | | | | | 4000 | 13.5 | 18.32 | 34.63 | 0.3864 | 0.01889 |
| | | | | | 4250 | 13.9 | 18.85 | 37.74 | 0.3872 | 0.01895 |
| | | | | P 255 40ZR 19 Pi | 3750 | 13.0 | 17.77 | 30.59 | 0.4782 | 0.01733 |
| | | | | Track pack option | 3875 | 13.2 | 18.09 | 31.93 | 0.4812 | 0.01731 |
| | | | | | 4000 | 13.4 | 18.40 | 33.28 | 0.4842 | 0.01729 |
| | | | | | 4250 | 13.8 | 19.01 | 35.97 | 0.4902 | 0.01725 |
| V8 Coupe | 5.0 | Automatic | RWD | P 235 50R 18 Pi | 3750 | 12.8 | 18.18 | 33.80 | 0.1497 | 0.02174 |
| | | | | | 3875 | 13.0 | 18.49 | 35.20 | 0.1512 | 0.02175 |
| | | | | | 4000 | 13.2 | 18.79 | 36.59 | 0.1527 | 0.02177 |
| | | | | | 4250 | 13.6 | 19.37 | 39.40 | 0.1557 | 0.02180 |
| | | | | P 245 45R 19 Pi | 3750 | 13.2 | 17.60 | 37.65 | 0.1199 | 0.02205 |
| | | | | | 3875 | 13.4 | 17.88 | 39.19 | 0.1203 | 0.02208 |
| | | | | | 4000 | 13.6 | 18.16 | 40.74 | 0.1207 | 0.02211 |
| | | | | | 4250 | 14.0 | 18.70 | 43.84 | 0.1214 | 0.02216 |
| | | | | P 255 40R 19 Go | 3750 | 12.6 | 18.37 | 30.28 | 0.2260 | 0.02123 |
| | | | | Shelby Brake option | 3875 | 12.8 | 18.73 | 31.40 | 0.2298 | 0.02122 |
| | | | | | 4000 | 13.0 | 19.07 | 32.53 | 0.2337 | 0.02122 |
| | | | | | 4250 | 13.3 | 19.73 | 34.77 | 0.2414 | 0.02120 |
| V8 Convt. | 5.0 | Manual | RWD | P 235 50R 18 Pi | 3750 | 13.0 | 17.80 | 27.60 | 0.4239 | 0.01955 |
| | | | | | 3875 | 13.2 | 18.11 | 28.99 | 0.4254 | 0.01957 |
| | | | | | 4000 | 13.4 | 18.42 | 30.39 | 0.4269 | 0.01958 |
| | | | | | 4250 | 13.8 | 18.99 | 33.19 | 0.4299 | 0.01961 |
| | | | | P 245 45R 19 Pi | 3750 | 13.4 | 17.23 | 31.54 | 0.3856 | 0.02002 |
| | | | | | 3875 | 13.7 | 17.52 | 33.08 | 0.3860 | 0.02005 |
| | | | | | 4000 | 13.9 | 17.80 | 34.63 | 0.3864 | 0.02007 |
| | | | | | 4250 | 14.3 | 18.33 | 37.74 | 0.3872 | 0.02013 |
| | | | | P 255 40R 19 Go | 3750 | 12.9 | 17.99 | 24.03 | 0.5047 | 0.01896 |
| | | | | Shelby Brake option | 3875 | 13.1 | 18.35 | 25.15 | 0.5085 | 0.01895 |
| | | | | | 4000 | 13.2 | 18.68 | 26.28 | 0.5124 | 0.01895 |
| | | | | | 4250 | 13.6 | 19.35 | 28.52 | 0.5201 | 0.01893 |
| V8 Convt. | 5.0 | Automatic | RWD | P 235 50R 18 Pi | 3750 | 13.1 | 17.64 | 33.80 | 0.1497 | 0.02292 |
| | | | | | 3875 | 13.3 | 17.95 | 35.20 | 0.1512 | 0.02293 |
| | | | | | 4000 | 13.5 | 18.25 | 36.59 | 0.1527 | 0.02295 |
| | | | | | 4250 | 13.9 | 18.83 | 39.40 | 0.1557 | 0.02297 |
| | | | | P 245 45R 19 Pi | 3750 | 13.6 | 17.09 | 37.65 | 0.1199 | 0.02323 |
| | | | | | 3875 | 13.8 | 17.38 | 39.19 | 0.1203 | 0.02326 |
| | | | | | 4000 | 14.0 | 17.65 | 40.74 | 0.1207 | 0.02329 |
| | | | | | 4250 | 14.4 | 18.19 | 43.84 | 0.1214 | 0.02334 |
| | | | | P 255 40R 19 Go | 3750 | 13.0 | 17.82 | 30.28 | 0.2260 | 0.02241 |
| | | | | Shelby Brake option | 3875 | 13.2 | 18.17 | 31.40 | 0.2298 | 0.02240 |
| | | | | | 4000 | 13.4 | 18.51 | 32.53 | 0.2337 | 0.02240 |
| | | | | | 4250 | 13.7 | 19.17 | 34.77 | 0.2414 | 0.02238 |
| Cal.-Special Coupe | 5.0 | Manual | RWD | P 245 45R 19 Pi | 3750 | 13.5 | 17.16 | 31.54 | 0.3856 | 0.02019 |
| | | | | | 3875 | 13.7 | 17.45 | 33.08 | 0.3860 | 0.02022 |
| | | | | | 4000 | 13.9 | 17.73 | 34.63 | 0.3864 | 0.02025 |
| | | | | | 4250 | 14.4 | 18.26 | 37.74 | 0.3872 | 0.02031 |
| Cal.-Special Coupe | 5.0 | Automatic | RWD | P 245 45R 19 Pi | 3750 | 13.6 | 17.01 | 37.65 | 0.1199 | 0.02341 |
| | | | | | 3875 | 13.8 | 17.31 | 39.19 | 0.1203 | 0.02343 |
| | | | | | 4000 | 14.1 | 17.58 | 40.74 | 0.1207 | 0.02346 |
| | | | | | 4250 | 14.5 | 18.11 | 43.84 | 0.1214 | 0.02352 |
| Cal.-Special Convt. | 5.0 | Manual | RWD | P 245 45R 19 Pi | 3750 | 13.9 | 16.68 | 31.54 | 0.3856 | 0.02137 |
| | | | | | 3875 | 14.1 | 16.97 | 33.08 | 0.3860 | 0.02140 |
| | | | | | 4000 | 14.3 | 17.24 | 34.63 | 0.3864 | 0.02143 |
| | | | | | 4250 | 14.8 | 17.78 | 37.74 | 0.3872 | 0.02148 |
| Cal.-Special Convt. | 5.0 | Automatic | RWD | P 245 45R 19 Pi | 3750 | 14.0 | 16.54 | 37.65 | 0.1199 | 0.02459 |
| | | | | | 3875 | 14.2 | 16.83 | 39.19 | 0.1203 | 0.02461 |
| | | | | | 4000 | 14.4 | 17.11 | 40.74 | 0.1207 | 0.02464 |
| | | | | | 4250 | 14.9 | 17.64 | 43.84 | 0.1214 | 0.02470 |
| BOSS | 5.0 | Manual | RWD | P 255 40R 19 Pzero | 3750 | 14.1 | 16.41 | 35.66 | 0.3913 | 0.0203 |
| | | | | P 285 35R 19 Pzero | 3875 | 14.3 | 16.73 | 37.01 | 0.3943 | 0.0203 |
| | | | | | 4000 | 14.5 | 17.03 | 38.35 | 0.3973 | 0.0203 |
| | | | | | 4250 | 14.9 | 17.62 | 41.04 | 0.4034 | 0.0202 |
| LAGUNA | 5.0 | Manual | RWD | P 255 40R 19 Corsa | 3750 | 14.7 | 15.79 | 40.52 | 0.3899 | 0.0200 |
| | | | | P 285 35R 19 Corsa | 3875 | 14.9 | 16.07 | 42.05 | 0.3929 | 0.0200 |
| | | | | | 4000 | 15.1 | 16.34 | 43.57 | 0.3959 | 0.0200 |
| | | | | | 4250 | 15.6 | 16.87 | 46.62 | 0.4018 | 0.0200 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 D258*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 D258 TRLHP Chart_ | 6/21/2011 | 2013 New Track D258 3.5L FWD RDM V4: | 43 | New Track Surface - Full Benefit |
| | | 2013 New Track D258 2.0L FWD GTDI RD | 43 | |
| 2013 D258 TRLHP Chart_ | 7/25/2011 | 2013 New Track D258 3.5L FWD RDM V4: | 43 | New Track Surface - Full Benefit |
| | | | | Added Job 1 19" Mi Tire |
| | | | | Added 20" Gdy Summer Tire |
| 2013 D258 TRLHP Chart_ | 10/13/2011 | 2013 New Track D258 3.5LL FWD V43 Co: | 43 | 18" Mi, 19" Gdy, 19" Mi & 20" Mi Tire |
| | | | | SRC Changes |
| 2013 D258 TRLHP Chart_ | 11/22/2011 | 2013 New Track D258 3.5LL FWD V43 Co: | 43 | Mi 19" & Mi 20" Tire SRC Changed |
| | | | | Base FWD CD Changed from .314 t0 .324 |
| 2013 D258 TRLHP Chart_ | 12/8/2011 | 2013 New Track D258 3.5LL FWD V43 Co: | 43 | Cd changed to .319 |
| 2013 D258 TRLHP Chart_ | 1/3/2012 | 2013 New Track D258 3.5LL FWD V43 Co: | 43 | Cd changed to .324 |

| | | Vehicle Description | | | | | | Track Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| D258 FWD | All | 6F | FWD | P 235 60R 17 | 4000 | 12.1 | 20.45 | 17.31 | 0.4692 | 0.02001 |
| | | | | | 4250 | 12.4 | 21.25 | 18.96 | 0.4742 | 0.02006 |
| | | | | | 4500 | 12.6 | 22.02 | 20.60 | 0.4791 | 0.02011 |
| | | | | | 4750 | 12.9 | 22.75 | 22.25 | 0.4841 | 0.02016 |
| | | | | | 5000 | 13.2 | 23.46 | 23.89 | 0.4890 | 0.02021 |
| | | | | P 235 55R 18 Mi | 4000 | 12.4 | 19.94 | 20.75 | 0.4848 | 0.01923 |
| | | | | | 4250 | 12.7 | 20.67 | 22.75 | 0.4913 | 0.01923 |
| | | | | | 4500 | 13.0 | 21.36 | 24.77 | 0.4979 | 0.01922 |
| | | | | | 4750 | 13.3 | 22.01 | 26.80 | 0.5045 | 0.01922 |
| | | | | | 5000 | 13.6 | 22.63 | 28.84 | 0.5112 | 0.01921 |
| | | | | 255 45R 19 Gdy | 4000 | 12.6 | 19.70 | 22.11 | 0.4674 | 0.01948 |
| | | | | (Job1 + 90 days) | 4250 | 12.9 | 20.42 | 24.16 | 0.4724 | 0.01950 |
| | | | | | 4500 | 13.2 | 21.11 | 26.23 | 0.4773 | 0.01951 |
| | | | | | 4750 | 13.5 | 21.76 | 28.30 | 0.4823 | 0.01953 |
| | | | | | 5000 | 13.8 | 22.38 | 30.38 | 0.4873 | 0.01954 |
| | | | | 255 45R 19 Mi | 4000 | 12.0 | 20.54 | 17.92 | 0.4736 | 0.01952 |
| | | | | (Job1) | 4250 | 12.3 | 21.31 | 19.76 | 0.4792 | 0.01954 |
| | | | | | 4500 | 12.6 | 22.03 | 21.62 | 0.4849 | 0.01956 |
| | | | | | 4750 | 12.9 | 22.72 | 23.49 | 0.4906 | 0.01958 |
| | | | | | 5000 | 13.2 | 23.38 | 25.37 | 0.4963 | 0.01960 |
| | | | | 245 45R 20 Mi | 4000 | 12.4 | 19.92 | 21.98 | 0.4420 | 0.01964 |
| | | | | | 4250 | 12.7 | 20.65 | 23.99 | 0.4462 | 0.01966 |
| | | | | | 4500 | 13.0 | 21.36 | 26.00 | 0.4503 | 0.01967 |
| | | | | | 4750 | 13.3 | 22.03 | 28.02 | 0.4545 | 0.01969 |
| | | | | | 5000 | 13.6 | 22.68 | 30.04 | 0.4587 | 0.01970 |
| | | | | 245 45R 20 Gdy | 4000 | 13.8 | 17.93 | 26.94 | 0.5663 | 0.01927 |
| | | | | | 4250 | 14.2 | 18.54 | 29.22 | 0.5786 | 0.01926 |
| | | | | | 4500 | 14.6 | 19.11 | 31.51 | 0.5909 | 0.01925 |
| | | | | | 4750 | 14.9 | 19.65 | 33.80 | 0.6032 | 0.01924 |

| | | | | | |
|---|---|---|---|---|---|
| **5000** | **15.3** | **20.16** | 36.09 | 0.6155 | 0.01923 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 D258*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 D258 TRLHP Chart_1 | 6/21/2011 | 2013 New Track D258 3.5L FWD RDM | 43 | New Track Surface - Full Benefit |
| | | 2013 New Track D258 2.0L FWD GTDI | 43 | |
| 2013 D258 TRLHP Chart_1 | 7/25/2011 | 2013 New Track D258 2.0L FWD GTDI | 43 | New Track Surface - Full Benefit<br>Added Job 1 19" Mi Tire<br>Added 20" Gdy Summer Tire |
| 2013 D258 TRLHP Chart_2 | 10/13/2011 | 2013 New Track D258 2.0L FWD GTDI | 43 | 18" Mi, 19" Gdy, 19" Mi & 20" Mi Tire<br>SRC & 2.0L aero Cd Change |
| 2013 D258 TRLHP Chart_3 | 11/22/2011 | | | Mi 19" & Mi 20" Tire SRC Changed<br>Vehicle Specific Updated |
| 2013 D258 TRLHP Chart_4 | 12/8/2011 | 2013 New Track D258 2.0L FWD GTDI | 43 | Cd changed to .308 |
| 2013 D258 TRLHP Chart_4 | 2/28/2012 | 2013 New Track D258 2.0L FWD GTDI | 43 | GTDI Only, Chg 18" Tire Press<br>to 35/35 psi |

| Vehicle Description | | | | | | | | Track Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| D258 FWD GTDI | 2.0L | 6F | FWD | P 235 60R 17 | 4000 | 11.1 | 22.20 | 22.14 | 0.2273 | 0.02004 |
| | | | | | 4250 | 11.4 | 23.03 | 23.79 | 0.2322 | 0.02009 |
| | | | | | 4500 | 11.7 | 23.82 | 25.43 | 0.2372 | 0.02014 |
| | | | | | 4750 | 12.0 | 24.57 | 27.08 | 0.2422 | 0.02019 |
| | | | | | 5000 | 12.2 | 25.29 | 28.72 | 0.2471 | 0.02024 |
| | | | | P 235 55R 18 Mi | 4000 | 11.3 | 21.97 | 24.35 | 0.2397 | 0.01925 |
| | | | | | 4250 | 11.6 | 22.74 | 26.27 | 0.2460 | 0.01924 |
| | | | | | 4500 | 11.8 | 23.47 | 28.20 | 0.2523 | 0.01924 |
| | | | | | 4750 | 12.2 | 24.15 | 30.14 | 0.2586 | 0.01924 |
| | | | | | 5000 | 12.4 | 24.81 | 32.09 | 0.2650 | 0.01923 |
| | | | | 255 45R 19 Gdy | 4000 | 11.6 | 21.33 | 26.94 | 0.2248 | 0.01952 |
| | | | | (Job1 + 90 days) | 4250 | 11.9 | 22.06 | 28.99 | 0.2297 | 0.01954 |
| | | | | | 4500 | 12.2 | 22.76 | 31.06 | 0.2347 | 0.01955 |
| | | | | | 4750 | 12.5 | 23.41 | 33.13 | 0.2397 | 0.01957 |
| | | | | | 5000 | 12.8 | 24.04 | 35.21 | 0.2447 | 0.01958 |
| | | | | 255 45R 19 Mi | 4000 | 11.1 | 22.31 | 22.75 | 0.2309 | 0.01956 |
| | | | | (Job1) | 4250 | 11.4 | 23.09 | 24.59 | 0.2366 | 0.01958 |
| | | | | | 4500 | 11.7 | 23.84 | 26.45 | 0.2422 | 0.01960 |
| | | | | | 4750 | 12.0 | 24.54 | 28.32 | 0.2479 | 0.01962 |
| | | | | | 5000 | 12.3 | 25.21 | 30.20 | 0.2537 | 0.01963 |
| | | | | 245 45R 20 Mi | 4000 | 11.5 | 21.55 | 26.80 | 0.2063 | 0.01958 |
| | | | | | 4250 | 11.8 | 22.31 | 28.81 | 0.2105 | 0.01960 |
| | | | | | 4500 | 12.1 | 23.03 | 30.82 | 0.2146 | 0.01961 |
| | | | | | 4750 | 12.4 | 23.71 | 32.84 | 0.2188 | 0.01963 |
| | | | | | 5000 | 12.7 | 24.36 | 34.87 | 0.2230 | 0.01964 |
| | | | | 245 45R 20 Gdy | 4000 | 12.8 | 19.25 | 31.76 | 0.3306 | 0.01921 |
| | | | | | 4250 | 13.2 | 19.86 | 34.04 | 0.3429 | 0.01920 |
| | | | | | 4500 | 13.6 | 20.43 | 36.33 | 0.3552 | 0.01919 |
| | | | | | 4750 | 14.0 | 20.97 | 38.62 | 0.3675 | 0.01918 |
| | | | | | 5000 | 14.4 | 21.48 | 40.91 | 0.3798 | 0.01917 |

**ROADLOAD CERTIFICATION SPECIFICATIONS** *2013 D258*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 D258 TRLHP Chart_1 | 6/21/2011 | 2013 New Track D258 AWD & AV | 43 | AWD 3.5L Target .314 Cd, New Track Surface |
| | | | | AWD SHO 3.5L Target .335 Cd |
| | | | | 17" Tire PPAP = 9.79, Tire psi = 38 |
| | | | | 18" Tire - Carryover, Tire psi = 32 |
| | | | | 19 " Tire press = 34 psi, 20" Tire Press =35 psi |
| 2013 D258 TRLHP Chart_1 | 7/25/2011 | 2013 New Track D258 AWD & AV | 43 | New Track Surface - Full Benefit |
| | | | | Added Job 1 19" Mi Tire & 20" GDY Sum Tire |
| 2013 D258 TRLHP Chart_2 | 10/13/2011 | 2013 New Track D258 AWD & AV | 43 | 18" Mi, 19" Gdy,19" Mi & 20" Mi Tire |
| | | | | SRC Changes, Mi 19 & 20" Tire SRC Chg |
| 2013 D258 TRLHP Chart_3 | 11/22/2011 | | | Base AWD CD Changed frm .314 to .324 |
| 2013 D258 TRLHP Chart_4 | 12/8/2011 | 2013 New Track D258 3.5LL AWI | 43 | Base AWD CD changed to .319 |
| | | | | & AWD GTDI to .330 from .335 |
| 2013 D258 TRLHP Chart_4 | 1/3/2012 | 2013 New Track D258 3.5LL AWI | 43 | Base AWD Cd changed to .324 |

| Vehicle Description | | | | | | | | Track Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| Base D258 AWD | All | 6F | AWD | P 235 60R 17 | 4000 | 13.2 | 18.76 | 21.25 | 0.6133 | 0.01879 |
| | | | | | 4250 | 13.4 | 19.54 | 22.90 | 0.6182 | 0.01884 |
| | | | | | 4500 | 13.7 | 20.28 | 24.54 | 0.6232 | 0.01888 |
| | | | | | 4750 | 14.0 | 20.99 | 26.19 | 0.6281 | 0.01893 |
| | | | | | 5000 | 14.2 | 21.68 | 27.83 | 0.6331 | 0.01898 |
| | | | | P 235 55R 18 Mi | 4000 | 13.5 | 18.35 | 24.69 | 0.6274 | 0.01802 |
| | | | | | 4250 | 13.8 | 19.06 | 26.69 | 0.6340 | 0.01801 |
| | | | | | 4500 | 14.1 | 19.73 | 28.71 | 0.6405 | 0.01801 |
| | | | | | 4750 | 14.4 | 20.36 | 30.74 | 0.6472 | 0.01801 |
| | | | | | 5000 | 14.7 | 20.98 | 32.77 | 0.6538 | 0.01800 |
| | | | | 255 45R 19 Gdy | 4000 | 13.6 | 18.13 | 26.05 | 0.6127 | 0.01824 |
| | | | | (Job1 + 90 days) | 4250 | 13.9 | 18.84 | 28.10 | 0.6177 | 0.01825 |
| | | | | | 4500 | 14.3 | 19.50 | 30.17 | 0.6227 | 0.01827 |
| | | | | | 4750 | 14.6 | 20.14 | 32.24 | 0.6277 | 0.01828 |
| | | | | | 5000 | 14.9 | 20.74 | 34.32 | 0.6327 | 0.01830 |
| | | | | 255 45R 19 Mi | 4000 | 13.1 | 18.84 | 21.86 | 0.6189 | 0.01828 |
| | | | | (Job1) | 4250 | 13.4 | 19.58 | 23.71 | 0.6245 | 0.01829 |
| | | | | | 4500 | 13.7 | 20.29 | 25.56 | 0.6302 | 0.01831 |
| | | | | | 4750 | 14.0 | 20.97 | 27.43 | 0.6359 | 0.01833 |
| | | | | | 5000 | 14.3 | 21.61 | 29.31 | 0.6417 | 0.01835 |
| | | | | 245 45R 20 Mi | 4000 | 13.5 | 18.36 | 25.89 | 0.5753 | 0.01854 |
| | | | | | 4250 | 13.8 | 19.08 | 27.90 | 0.5794 | 0.01856 |
| | | | | | 4500 | 14.1 | 19.77 | 29.91 | 0.5836 | 0.01857 |
| | | | | | 4750 | 14.4 | 20.43 | 31.93 | 0.5878 | 0.01859 |
| | | | | | 5000 | 14.7 | 21.05 | 33.96 | 0.5920 | 0.01861 |
| | | | | 245 45R 20 Gdy | 4000 | 14.8 | 16.67 | 30.85 | 0.6995 | 0.01817 |
| | | | | | 4250 | 15.2 | 17.26 | 33.14 | 0.7118 | 0.01816 |
| | | | | | 4500 | 15.6 | 17.82 | 35.42 | 0.7241 | 0.01815 |
| | | | | | 4750 | 16.0 | 18.36 | 37.71 | 0.7365 | 0.01814 |
| | | | | | 5000 | 16.4 | 18.87 | 40.00 | 0.7488 | 0.01813 |
| D258 GTDI AWD SHO | All | 6F | AWD | P 235 60R 17 | 4000 | 13.5 | 18.31 | 28.68 | 0.3087 | 0.02289 |
| | | | | | 4250 | 13.8 | 19.07 | 30.32 | 0.3137 | 0.02294 |
| | | | | | 4500 | 14.0 | 19.81 | 31.96 | 0.3186 | 0.02299 |
| | | | | | 4750 | 14.3 | 20.51 | 33.61 | 0.3236 | 0.02304 |
| | | | | | 5000 | 14.6 | 21.19 | 35.26 | 0.3286 | 0.02309 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **P 235 55R 18 Mi** | **4000** | **13.8** | **17.91** | 32.09 | 0.3245 | 0.02210 |
| | **4250** | **14.1** | **18.61** | 34.10 | 0.3311 | 0.02209 |
| | **4500** | **14.4** | **19.28** | 36.11 | 0.3377 | 0.02209 |
| | **4750** | **14.7** | **19.91** | 38.14 | 0.3443 | 0.02209 |
| | **5000** | **15.0** | **20.52** | 40.18 | 0.3509 | 0.02208 |
| **255 45R 19 Gdy** | **4000** | **14.0** | **17.70** | 33.49 | 0.3068 | 0.02237 |
| **(Job1 + 90 days)** | **4250** | **14.3** | **18.39** | 35.55 | 0.3117 | 0.02239 |
| | **4500** | **14.6** | **19.06** | 37.61 | 0.3167 | 0.02240 |
| | **4750** | **14.9** | **19.69** | 39.68 | 0.3217 | 0.02242 |
| | **5000** | **15.2** | **20.29** | 41.76 | 0.3267 | 0.02244 |
| **255 45R 19 Mi** | **4000** | **13.5** | **18.27** | 29.89 | 0.3251 | 0.02215 |
| **(Job1)** | **4250** | **13.8** | **18.99** | 31.80 | 0.3316 | 0.02215 |
| | **4500** | **14.1** | **19.68** | 33.72 | 0.3383 | 0.02215 |
| | **4750** | **14.4** | **20.33** | 35.66 | 0.3450 | 0.02215 |
| | **5000** | **14.7** | **20.96** | 37.61 | 0.3517 | 0.02215 |
| **245 45R 20 Mi** | **4000** | **13.7** | **18.02** | 32.92 | 0.2906 | 0.02219 |
| | **4250** | **14.0** | **18.77** | 34.77 | 0.2950 | 0.02219 |
| | **4500** | **14.3** | **19.48** | 36.62 | 0.2993 | 0.02219 |
| | **4750** | **14.5** | **20.18** | 38.46 | 0.3037 | 0.02219 |
| | **5000** | **14.8** | **20.84** | 40.31 | 0.3080 | 0.02219 |
| **245 45R 20 Gdy** | **4000** | **15.2** | **16.31** | 38.13 | 0.4072 | 0.02206 |
| | **4250** | **15.5** | **16.90** | 40.41 | 0.4195 | 0.02205 |
| | **4500** | **15.9** | **17.46** | 42.70 | 0.4318 | 0.02204 |
| | **4750** | **16.3** | **18.00** | 44.99 | 0.4441 | 0.02203 |
| | **5000** | **16.7** | **18.51** | 47.28 | 0.4564 | 0.02202 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 D258 Police*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 D258 TRLHP Chart_1 | 6/21/2011 | 2013 Police New Track D258 FWD RD | 43 | .379 Cd, 27.23 FA |
| | | | | New Track Surface - Full Benefit |
| 2013 D258 TRLHP Chart_2 | 10/13/2011 | 2013 Police New Track D258 FWD RD | 43 | No Changes |
| 2013 D258 TRLHP Chart_3 | 11/22/2011 | | | CD Changed from .379 to .370 |
| | | | | Coasted FWD Police Vehicle |
| 2013 D258 TRLHP Chart_4 | 12/8/2011 | 2013 Police New Track D258 FWD RD | 43 | No Changes |

| Vehicle Description | | | | | | | | Track Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| D258 FWD | All | 6F | FWD | 245 55R 18 | 4000 | 14.1 | 17.55 | 29.30 | 0.4050 | 0.02247 |
| | | | | | 4250 | 14.5 | 18.14 | 31.79 | 0.4127 | 0.02248 |
| | | | | | 4500 | 14.9 | 18.71 | 34.28 | 0.4203 | 0.02249 |
| | | | | | 4750 | 15.3 | 19.24 | 36.77 | 0.4280 | 0.02250 |
| | | | | | 5000 | 15.6 | 19.75 | 39.27 | 0.4357 | 0.02251 |
| D258 AWD | All | 6F | AWD | 245 55R 18 | 4000 | 15.6 | 15.88 | 31.30 | 0.6998 | 0.02018 |
| | | | | | 4250 | 16.0 | 16.47 | 33.78 | 0.7074 | 0.02019 |
| | | | | | 4500 | 16.3 | 17.02 | 36.27 | 0.7151 | 0.02020 |
| | | | | | 4750 | 16.7 | 17.55 | 38.77 | 0.7228 | 0.02021 |
| | | | | | 5000 | 17.1 | 18.05 | 41.26 | 0.7304 | 0.02022 |
| D258 GTDI AWD | All | 6F | AWD | 245 55R 18 | 4000 | 15.7 | 15.70 | 38.59 | 0.4060 | 0.02369 |
| | | | | | 4250 | 16.1 | 16.28 | 41.08 | 0.4137 | 0.02370 |
| | | | | | 4500 | 16.5 | 16.83 | 43.57 | 0.4213 | 0.02371 |
| | | | | | 4750 | 16.9 | 17.36 | 46.06 | 0.4290 | 0.02372 |
| | | | | | 5000 | 17.3 | 17.86 | 48.55 | 0.4366 | 0.02373 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 V227 Transit Connect*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 V227TRLHP Chart_2 | 5/2/2012 | 2012 3.2 percent constant force . | 43 | Replaced new compound tire RRC with 8.73 SRC & 8.198 RRC Baked Generic 9.49 SRC & 8.91 RRC Broken-in Veh Specific .355 Cd used for 17 counts improvement from 2010. 3.2% Constant Force adj for new track 3.96 FDR Parasitic A1 applied Hp ASTM Rounded |

| | Vehicle Description | | | | | | | Track Coefficients | 3 Term coefs | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| Transit Connect Van | 2.0 | Auto | FWD | P 205 65R 15 | 3625 | 15.0 | 15.00 | 24.49 | 0.3759 | 0.02756 |
| | | | | | 3750 | 15.1 | 15.38 | 25.35 | 0.3793 | 0.02755 |
| | | | | | 3875 | 15.2 | 15.75 | 26.21 | 0.3826 | 0.02755 |
| | | | | | 4000 | 15.4 | 16.11 | 27.07 | 0.3860 | 0.02754 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 V227 Transit Connect*

| | | | | |
|---|---|---|---|---|
| 2013 V227 TRLHP Chart_2 | 5/2/2012 | 2012 3.2 percent constant force . | 43 | Replaced new compound tire RRC with 8.73 SRC & 8.198 RRC Baked Generic 9.49 SRC & 8.91 RRC Broken-in Veh Specific .355 Cd used for 17 counts improvement from 2010. 3.2% Constant Force adj for new track 3.96 FDR Parasitic A1 applied Hp ASTM Rounded |

| | Vehicle Description | | | | | | | Track Coefficients | 3 Term coefs | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| Transit Connect Wagon | 2.0 | Auto | FWD | P 205 65R 15 | 3625 | 15.1 | 14.82 | 24.42 | 0.4036 | 0.02759 |
| | | | | | 3750 | 15.3 | 15.19 | 25.28 | 0.4069 | 0.02759 |
| | | | | | 3875 | 15.4 | 15.56 | 26.13 | 0.4103 | 0.02758 |
| | | | | | 4000 | 15.5 | 15.92 | 26.99 | 0.4136 | 0.02758 |

# Index for Single Roll Settings 2013 Model Year Truck

ROADLOAD CERTIFICATION SPECIFICATIONS — *2013 Econoline*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13Econoline_chart.xls | 7/21/2011 | 11EconRDMVer43.1.xls | 43 | Carryover |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | 3 Term coefs | | |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| E150 | All | All | RWD | LT 225 75R 16 AS | 5250 | 22.1 | 14.67 | 39.16 | 0.8164 | 0.03441 |
| | | | | | 5500 | 22.5 | 15.14 | 40.79 | 0.8339 | 0.03441 |
| | | | | | 6000 | 23.1 | 16.04 | 44.04 | 0.8689 | 0.03441 |
| | | | | | 6500 | 23.8 | 16.89 | 47.29 | 0.9039 | 0.03441 |
| | | | | | 7000 | 24.5 | 17.69 | 50.54 | 0.9389 | 0.03441 |
| | | | | | 7500 | 25.1 | 18.45 | 53.78 | 0.9738 | 0.03441 |
| | | | | LT 245 75R 16 AS | 5250 | 21.9 | 14.86 | 38.30 | 0.7502 | 0.03525 |
| | | | | | 5500 | 22.2 | 15.35 | 39.77 | 0.7661 | 0.03525 |
| | | | | | 6000 | 22.8 | 16.31 | 42.69 | 0.7975 | 0.03525 |
| | | | | | 6500 | 23.3 | 17.22 | 45.55 | 0.8283 | 0.03525 |
| | | | | | 7000 | 23.9 | 18.09 | 48.37 | 0.8587 | 0.03525 |
| | | | | | 7500 | 24.5 | 18.93 | 51.14 | 0.8885 | 0.03525 |
| E250 | All | All | RWD | LT 225 75R 16 AS | 5250 | 22.9 | 14.19 | 39.16 | 0.8164 | 0.03667 |
| | | | | | 5500 | 23.2 | 14.65 | 40.79 | 0.8339 | 0.03667 |
| | | | | | 6000 | 23.9 | 15.53 | 44.04 | 0.8689 | 0.03667 |
| | | | | | 6500 | 24.6 | 16.37 | 47.29 | 0.9039 | 0.03667 |
| | | | | | 7000 | 25.2 | 17.16 | 50.54 | 0.9389 | 0.03667 |
| | | | | | 7500 | 25.9 | 17.91 | 53.78 | 0.9738 | 0.03667 |
| | | | | LT 245 75R 16 AS | 5250 | 22.6 | 14.36 | 38.30 | 0.7502 | 0.03752 |
| | | | | | 5500 | 22.9 | 14.85 | 39.77 | 0.7661 | 0.03752 |
| | | | | | 6000 | 23.5 | 15.78 | 42.69 | 0.7975 | 0.03752 |
| | | | | | 6500 | 24.1 | 16.68 | 45.55 | 0.8283 | 0.03752 |
| | | | | | 7000 | 24.7 | 17.54 | 48.37 | 0.8587 | 0.03752 |
| | | | | | 7500 | 25.2 | 18.37 | 51.14 | 0.8885 | 0.03752 |
| E350 | 5.4L | All | RWD | LT 225 75R 16 AS | 5500 | 23.5 | 14.50 | 40.79 | 0.8339 | 0.03739 |
| | | | | | 6000 | 24.1 | 15.38 | 44.04 | 0.8689 | 0.03739 |
| | | | | | 6500 | 24.8 | 16.21 | 47.29 | 0.9039 | 0.03739 |
| | | | | | 7000 | 25.5 | 17.00 | 50.54 | 0.9389 | 0.03739 |
| | | | | | 7500 | 26.1 | 17.75 | 53.78 | 0.9738 | 0.03739 |
| | | | | | 8000 | 26.8 | 18.46 | 57.01 | 1.0086 | 0.03739 |
| | | | | LT 245 75R 16 AS | 5500 | 23.2 | 14.69 | 39.77 | 0.7661 | 0.03824 |
| | | | | | 6000 | 23.8 | 15.62 | 42.69 | 0.7975 | 0.03824 |
| | | | | | 6500 | 24.3 | 16.52 | 45.55 | 0.8283 | 0.03824 |
| | | | | | 7000 | 24.9 | 17.37 | 48.37 | 0.8587 | 0.03824 |
| | | | | | 7500 | 25.5 | 18.19 | 51.14 | 0.8885 | 0.03824 |
| | | | | | 8000 | 26.0 | 18.99 | 53.86 | 0.9178 | 0.03824 |
| E350 | 6.8L/6.0LD | All | RWD | LT 225 75R 16 AS | 5500 | 23.8 | 14.27 | 44.08 | 0.8806 | 0.03626 |
| | | | | | 6000 | 24.5 | 15.14 | 47.33 | 0.9157 | 0.03626 |
| | | | | | 6500 | 25.2 | 15.97 | 50.58 | 0.9507 | 0.03626 |
| | | | | | 7000 | 25.8 | 16.75 | 53.82 | 0.9856 | 0.03626 |
| | | | | | 7500 | 26.5 | 17.50 | 57.06 | 1.0205 | 0.03626 |
| | | | | | 8000 | 27.2 | 18.20 | 60.30 | 1.0553 | 0.03626 |
| | | | | LT 245 75R 16 AS | 5500 | 23.5 | 14.46 | 42.93 | 0.8093 | 0.03723 |
| | | | | | 6000 | 24.1 | 15.38 | 45.85 | 0.8407 | 0.03723 |
| | | | | | 6500 | 24.7 | 16.26 | 48.71 | 0.8715 | 0.03723 |
| | | | | | 7000 | 25.3 | 17.11 | 51.53 | 0.9019 | 0.03723 |
| | | | | | 7500 | 25.9 | 17.93 | 54.30 | 0.9317 | 0.03723 |
| | | | | | 8000 | 26.4 | 18.72 | 57.02 | 0.9610 | 0.03723 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 Econoline Incomplete*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13Econoline_chart.xls | 7/21/2011 | 2008 super Econ_1rdm.xls | 41 | Carryover |

| Vehicle Description | | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| E450 C/A | All | All | RWD | All | 7500 | 37.7 | 12.32 | 79.89 | 0.7912 | 0.06520 |
| 56.0 ft^2 | | | | | 8000 | 38.3 | 12.91 | 83.07 | 0.8254 | 0.06520 |
| | | | | | 8500 | 39.0 | 13.49 | 86.25 | 0.8596 | 0.06520 |
| | | | | | 9000 | 39.6 | 14.05 | 89.41 | 0.8937 | 0.06520 |
| | | | | | 9500 | 40.3 | 14.59 | 92.58 | 0.9278 | 0.06520 |
| | | | | | 10000 | 40.9 | 15.11 | 95.73 | 0.9618 | 0.06520 |
| | | | | | 10500 | 41.6 | 15.62 | 98.89 | 0.9957 | 0.06520 |
| | | | | | 11000 | 42.2 | 16.11 | 102.03 | 1.0296 | 0.06520 |
| | | | | | 11500 | 42.8 | 16.59 | 105.18 | 1.0635 | 0.06520 |
| | | | | | 12000 | 43.5 | 17.05 | 108.31 | 1.0972 | 0.06520 |
| E450 w/box | All | All | RWD | All | 7500 | 58.4 | 7.94 | 116.89 | 0.7912 | 0.11274 |
| 72.0 ft^2 | | | | | 8000 | 59.1 | 8.37 | 120.06 | 0.8254 | 0.11274 |
| | | | | | 8500 | 59.7 | 8.80 | 123.24 | 0.8596 | 0.11274 |
| | | | | | 9000 | 60.4 | 9.22 | 126.41 | 0.8937 | 0.11274 |
| | | | | | 9500 | 61.0 | 9.63 | 129.57 | 0.9278 | 0.11274 |
| | | | | | 10000 | 61.7 | 10.03 | 132.73 | 0.9618 | 0.11274 |
| | | | | | 10500 | 62.3 | 10.42 | 135.88 | 0.9957 | 0.11274 |
| | | | | | 11000 | 63.0 | 10.80 | 139.03 | 1.0296 | 0.11274 |
| | | | | | 11500 | 63.6 | 11.18 | 142.17 | 1.0635 | 0.11274 |
| | | | | | 12000 | 64.3 | 11.55 | 145.31 | 1.0972 | 0.11274 |
| E350 Strip Chassis | All | All | RWD | All | 7500 | 35.6 | 13.02 | 79.89 | 0.7912 | 0.05907 |
| 49.0 ft^2 | | | | | 8000 | 36.3 | 13.64 | 83.07 | 0.8254 | 0.05907 |
| | | | | | 8500 | 36.9 | 14.23 | 86.25 | 0.8596 | 0.05907 |
| | | | | | 9000 | 37.6 | 14.81 | 89.41 | 0.8937 | 0.05907 |
| | | | | | 9500 | 38.2 | 15.36 | 92.58 | 0.9278 | 0.05907 |
| | | | | | 10000 | 38.9 | 15.90 | 95.73 | 0.9618 | 0.05907 |
| | | | | | 10500 | 39.5 | 16.42 | 98.89 | 0.9957 | 0.05907 |
| | | | | | 11000 | 40.2 | 16.93 | 102.03 | 1.0296 | 0.05907 |
| | | | | | 11500 | 40.8 | 17.42 | 105.18 | 1.0635 | 0.05907 |
| | | | | | 12000 | 41.4 | 17.89 | 108.31 | 1.0972 | 0.05907 |
| E350 C/A w/Box SRW | All | All | RWD | All | 7000 | 46.0 | 9.43 | 75.07 | 0.6802 | 0.09442 |
| 60.0 ft^2 | | | | | 7500 | 46.6 | 9.97 | 77.78 | 0.7094 | 0.09442 |
| | | | | | 8000 | 47.1 | 10.51 | 80.49 | 0.7386 | 0.09442 |
| | | | | | 8500 | 47.7 | 11.04 | 83.15 | 0.7672 | 0.09442 |
| | | | | | 9000 | 48.2 | 11.55 | 85.76 | 0.7953 | 0.09442 |
| | | | | | 9500 | 48.7 | 12.06 | 88.33 | 0.8230 | 0.09442 |
| | | | | | 10000 | 49.3 | 12.56 | 90.85 | 0.8501 | 0.09442 |
| | | | | | 10500 | 49.8 | 13.06 | 93.32 | 0.8767 | 0.09442 |
| | | | | | 11000 | 50.3 | 13.54 | 95.74 | 0.9028 | 0.09442 |
| | | | | | 11500 | 50.7 | 14.02 | 98.11 | 0.9283 | 0.09442 |
| | | | | | 12000 | 51.2 | 14.50 | 100.44 | 0.9534 | 0.09442 |
| E250 C/A w/Box | 4.6L | All | RWD | All | 6000 | 41.8 | 8.89 | 67.04 | 0.6414 | 0.08574 |
| 54.5 ft^2 | | | | | 6500 | 42.4 | 9.48 | 70.23 | 0.6758 | 0.08574 |
| | | | | | 7000 | 43.1 | 10.05 | 73.42 | 0.7102 | 0.08574 |
| | | | | | 7500 | 43.8 | 10.61 | 76.61 | 0.7444 | 0.08574 |
| | | | | | 8000 | 44.4 | 11.15 | 79.78 | 0.7787 | 0.08574 |
| | | | | | 8500 | 45.1 | 11.67 | 82.96 | 0.8128 | 0.08574 |
| | | | | | 9000 | 45.7 | 12.18 | 86.13 | 0.8470 | 0.08574 |
| | | | | | 9500 | 46.4 | 12.68 | 89.29 | 0.8810 | 0.08574 |
| | | | | | 10000 | 47.0 | 13.16 | 92.45 | 0.9150 | 0.08574 |
| | | | | | 10500 | 47.7 | 13.63 | 95.60 | 0.9490 | 0.08574 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| E-350 C/A DRW<br>50.0 ft^2 | All | All | RWD | All | 7500 | 39.9 | 11.65 | 73.55 | 1.1770 | 0.06673 |
| | | | | | 8000 | 40.6 | 12.18 | 78.48 | 1.1880 | 0.06673 |
| | | | | | 8500 | 41.3 | 12.73 | 82.66 | 1.1989 | 0.06673 |
| | | | | | 9000 | 42.1 | 13.17 | 87.12 | 1.2422 | 0.06673 |
| | | | | | 9500 | 43.2 | 13.66 | 92.33 | 1.2899 | 0.06673 |
| | | | | | 10000 | 44.0 | 14.25 | 96.87 | 1.3226 | 0.06673 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 Edge/MKX*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13U38X_chart.2.xls | 9/27/2011 | 13U38X_FWD/AWD.2_RDM.xls | 43 | Revise 17" tire RR |
| 13U38X_chart.1.xls | 8/15/2011 | 13U38X_FWD/AWD.1_RDM.xls | 43 | Revise 22" tire RR |
| 13U38X_chart.xls | 6/16/2011 | 13U38X_FWD/AWD_RDM.xls | 43 | Add 22" tire to MKX |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| Edge | 2.0L | Auto | FWD | P 235 65R 17 | 4250 | 14.3 | 18.43 | 30.09 | 0.3629 | 0.02348 |
| | | | | | 4500 | 14.6 | 19.07 | 32.23 | 0.3690 | 0.02351 |
| | | | | | 4750 | 14.9 | 19.67 | 34.37 | 0.3750 | 0.02354 |
| | | | | P 245 60R 18 | 4250 | 12.8 | 20.54 | 19.97 | 0.3483 | 0.02348 |
| | | | | | 4500 | 13.1 | 21.31 | 21.58 | 0.3541 | 0.02350 |
| | | | | | 4750 | 13.3 | 22.04 | 23.19 | 0.3600 | 0.02353 |
| | | | | P 245 50R 20 | 4250 | 14.9 | 17.69 | 35.22 | 0.3651 | 0.02317 |
| | | | | | 4500 | 15.2 | 18.29 | 37.57 | 0.3714 | 0.02317 |
| | | | | | 4750 | 15.6 | 18.86 | 39.92 | 0.3776 | 0.02317 |
| Edge | 3.5L/3.7L | Auto | FWD | P 235 65R 17 | 4250 | 15.3 | 17.19 | 34.76 | 0.2997 | 0.02597 |
| | | | | | 4500 | 15.6 | 17.81 | 36.90 | 0.3057 | 0.02600 |
| | | | | | 4750 | 16.0 | 18.40 | 39.05 | 0.3118 | 0.02602 |
| | | | | P 245 60R 18 | 4250 | 13.8 | 19.03 | 24.55 | 0.2874 | 0.02591 |
| | | | | | 4500 | 14.1 | 19.77 | 26.16 | 0.2932 | 0.02593 |
| | | | | | 4750 | 14.4 | 20.48 | 27.78 | 0.2990 | 0.02596 |
| | | | | P 245 50R 20 | 4250 | 15.9 | 16.56 | 39.79 | 0.3044 | 0.02559 |
| | | | | | 4500 | 16.2 | 17.14 | 42.15 | 0.3107 | 0.02559 |
| | | | | | 4750 | 16.6 | 17.70 | 44.49 | 0.3170 | 0.02560 |
| Edge Sport | 3.7L | Auto | FWD | P 265 40R 22 | 4250 | 16.3 | 16.14 | 39.12 | 0.2719 | 0.02776 |
| | | | | | 4500 | 16.7 | 16.70 | 41.67 | 0.2770 | 0.02776 |
| | | | | | 4750 | 17.0 | 17.24 | 44.22 | 0.2821 | 0.02776 |
| MKX | 3.7L | Auto | FWD | P 245 60R 18 | 4250 | 14.0 | 18.77 | 24.55 | 0.2874 | 0.02647 |
| | | | | | 4500 | 14.3 | 19.51 | 26.16 | 0.2932 | 0.02649 |
| | | | | | 4750 | 14.5 | 20.22 | 27.78 | 0.2990 | 0.02652 |
| | | | | P 245 50R 20 | 4250 | 16.1 | 16.37 | 39.79 | 0.3044 | 0.02615 |
| | | | | | 4500 | 16.4 | 16.95 | 42.15 | 0.3107 | 0.02615 |
| | | | | | 4750 | 16.8 | 17.51 | 44.49 | 0.3170 | 0.02616 |
| | | | | P 265 40R 22 | 4250 | 15.7 | 16.71 | 39.12 | 0.2719 | 0.02607 |
| | | | | | 4500 | 16.1 | 17.28 | 41.67 | 0.2770 | 0.02607 |
| | | | | | 4750 | 16.5 | 17.83 | 44.22 | 0.2821 | 0.02607 |
| Edge | 3.5L/3.7L | Auto | AWD | P 235 65R 17 | 4500 | 17.7 | 15.74 | 42.60 | 0.2995 | 0.03000 |
| | | | | | 4750 | 18.0 | 16.30 | 44.75 | 0.3055 | 0.03003 |
| | | | | | 5000 | 18.3 | 16.85 | 46.89 | 0.3116 | 0.03005 |
| | | | | P 245 60R 18 | 4500 | 16.1 | 17.31 | 31.84 | 0.2783 | 0.02996 |
| | | | | | 4750 | 16.4 | 17.97 | 33.46 | 0.2841 | 0.02999 |
| | | | | | 5000 | 16.6 | 18.62 | 35.08 | 0.2899 | 0.03001 |
| | | | | P 245 50R 20 | 4500 | 18.2 | 15.27 | 47.83 | 0.2947 | 0.02963 |
| | | | | | 4750 | 18.6 | 15.80 | 50.17 | 0.3010 | 0.02963 |
| | | | | | 5000 | 18.9 | 16.32 | 52.52 | 0.3073 | 0.02963 |
| Edge Sport | 3.7L | Auto | AWD | P 265 40R 22 | 4500 | 18.5 | 15.02 | 47.32 | 0.2507 | 0.03160 |
| | | | | | 4750 | 18.9 | 15.54 | 49.88 | 0.2558 | 0.03160 |
| | | | | | 5000 | 19.3 | 16.04 | 52.44 | 0.2609 | 0.03160 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 Edge/MKX*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13U38X_chart.2.xls | 9/27/2011 | 13U38X_FWD/AWD.2_RDM.xls | 43 | Revise 17" tire RR |
| 13U38X_chart.1.xls | 8/15/2011 | 13U38X_FWD/AWD.1_RDM.xls | 43 | Revise 22" tire RR |
| 13U38X_chart.xls | 6/16/2011 | 13U38X_FWD/AWD_RDM.xls | 43 | Add 22" tire to MKX |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| MKX | 3.7L | Auto | AWD | P 245 60R 18 | 4500 | 16.2 | 17.19 | 31.84 | 0.2783 | 0.03030 |
| | | | | | 4750 | 16.5 | 17.85 | 33.46 | 0.2841 | 0.03033 |
| | | | | | 5000 | 16.7 | 18.49 | 35.08 | 0.2899 | 0.03035 |
| | | | | P 245 50R 20 | 4500 | 18.3 | 15.17 | 47.83 | 0.2947 | 0.02997 |
| | | | | | 4750 | 18.7 | 15.71 | 50.17 | 0.3010 | 0.02997 |
| | | | | | 5000 | 19.0 | 16.23 | 52.52 | 0.3073 | 0.02997 |
| | | | | P 265 40R 22 | 4500 | 18.0 | 15.49 | 47.32 | 0.2507 | 0.02991 |
| | | | | | 4750 | 18.3 | 16.02 | 49.88 | 0.2558 | 0.02991 |
| | | | | | 5000 | 18.7 | 16.52 | 52.44 | 0.2609 | 0.02991 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 C520 TRLHP*

| Coverage Chart | | Date | RDM file | | Version | Comments |
|---|---|---|---|---|---|---|
| C520 | | 9/12/2011 | 2013 C520 futuring V44.xls | | 44 | Tire data subject to change |
| | | | | | | updated parasitics, new track coast down |
| C520 | | 2/17/2012 | | | 44 | New Tieback process |

| Vehicle Description | | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | 3 Term coefs | | |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| C520 1.6 | All | Auto | FWD | P235/55R17 | 3750 | 13.0 | 17.91 | 21.18 | 0.4050 | 0.02232 |
| | | | | | 3875 | 13.1 | 18.36 | 21.88 | 0.4055 | 0.02233 |
| | | | | | 4000 | 13.2 | 18.81 | 22.59 | 0.4060 | 0.02234 |
| | | | | | 4250 | 13.4 | 19.68 | 24.00 | 0.4069 | 0.02236 |
| | | | | P235/50R18 | 3750 | 13.1 | 17.76 | 21.26 | 0.4198 | 0.02231 |
| | | | | | 3875 | 13.2 | 18.21 | 21.96 | 0.4208 | 0.02232 |
| | | | | | 4000 | 13.3 | 18.64 | 22.67 | 0.4219 | 0.02233 |
| | | | | | 4250 | 13.5 | 19.50 | 24.08 | 0.4239 | 0.02235 |
| | | | | P235/45R19 | 3750 | 13.0 | 17.83 | 21.33 | 0.4068 | 0.02238 |
| | | | | | 3875 | 13.1 | 18.28 | 22.06 | 0.4075 | 0.02239 |
| | | | | | 4000 | 13.2 | 18.72 | 22.79 | 0.4081 | 0.02240 |
| | | | | | 4250 | 13.4 | 19.57 | 24.27 | 0.4095 | 0.02243 |
| C520 1.6 | All | Auto | AWD | P235/55R17 | 3750 | 13.7 | 17.00 | 23.60 | 0.4078 | 0.02336 |
| | | | | | 3875 | 13.8 | 17.44 | 24.31 | 0.4083 | 0.02337 |
| | | | | | 4000 | 13.9 | 17.87 | 25.02 | 0.4088 | 0.02338 |
| | | | | | 4250 | 14.1 | 18.71 | 26.45 | 0.4098 | 0.02340 |
| | | | | P235/50R18 | 3750 | 13.8 | 16.87 | 23.67 | 0.4228 | 0.02334 |
| | | | | | 3875 | 13.9 | 17.30 | 24.39 | 0.4238 | 0.02335 |
| | | | | | 4000 | 14.0 | 17.72 | 25.10 | 0.4249 | 0.02336 |
| | | | | | 4250 | 14.2 | 18.55 | 26.52 | 0.4270 | 0.02338 |
| | | | | P235/45R19 | 3750 | 13.7 | 16.95 | 23.74 | 0.4096 | 0.02340 |
| | | | | | 3875 | 13.8 | 17.37 | 24.48 | 0.4103 | 0.02342 |
| | | | | | 4000 | 13.9 | 17.79 | 25.22 | 0.4110 | 0.02343 |
| | | | | | 4250 | 14.1 | 18.61 | 26.71 | 0.4124 | 0.02345 |
| C520 FWD 2.5 | All | Auto | FWD | P235/55R17 | 3750 | 12.9 | 17.97 | 21.19 | 0.4042 | 0.02219 |
| | | | | | 3875 | 13.0 | 18.43 | 21.89 | 0.4047 | 0.02220 |
| | | | | | 4000 | 13.1 | 18.87 | 22.60 | 0.4051 | 0.02221 |
| | | | | | 4250 | 13.3 | 19.75 | 24.01 | 0.4061 | 0.02223 |
| | | | | P235/50R18 | 3750 | 13.0 | 17.82 | 21.27 | 0.4190 | 0.02218 |
| | | | | | 3875 | 13.1 | 18.27 | 21.97 | 0.4200 | 0.02219 |
| | | | | | 4000 | 13.2 | 18.71 | 22.68 | 0.4211 | 0.02220 |
| | | | | | 4250 | 13.4 | 19.57 | 24.09 | 0.4231 | 0.02222 |
| | | | | P235/45R19 | 3750 | 13.0 | 17.90 | 21.34 | 0.4060 | 0.02225 |
| | | | | | 3875 | 13.1 | 18.35 | 22.07 | 0.4067 | 0.02226 |
| | | | | | 4000 | 13.2 | 18.78 | 22.81 | 0.4073 | 0.02227 |
| | | | | | 4250 | 13.4 | 19.63 | 24.28 | 0.4087 | 0.02230 |
| C520 2.0 | All | Auto | FWD | P235/55R17 | 3750 | 13.4 | 17.36 | 21.09 | 0.4119 | 0.02344 |
| | | | | | 3875 | 13.5 | 17.81 | 21.79 | 0.4124 | 0.02345 |
| | | | | | 4000 | 13.6 | 18.24 | 22.50 | 0.4129 | 0.02346 |
| | | | | | 4250 | 13.8 | 19.10 | 23.91 | 0.4139 | 0.02348 |
| | | | | P235/50R18 | 3750 | 13.5 | 17.23 | 21.17 | 0.4267 | 0.02343 |
| | | | | | 3875 | 13.6 | 17.66 | 21.87 | 0.4278 | 0.02344 |
| | | | | | 4000 | 13.7 | 18.09 | 22.58 | 0.4288 | 0.02345 |
| | | | | | 4250 | 13.9 | 18.93 | 23.99 | 0.4309 | 0.02347 |
| | | | | P235/45R19 | 3750 | 13.4 | 17.29 | 21.24 | 0.4138 | 0.02350 |
| | | | | | 3875 | 13.5 | 17.73 | 21.97 | 0.4144 | 0.02351 |
| | | | | | 4000 | 13.6 | 18.16 | 22.71 | 0.4151 | 0.02352 |
| | | | | | 4250 | 13.8 | 19.00 | 24.18 | 0.4164 | 0.02354 |
| C520 2.0 | All | Auto | AWD | P235/55R17 | 3750 | 14.1 | 16.51 | 23.51 | 0.4147 | 0.02448 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 C520 TRLHP*

| Coverage Chart | | Date | | RDM file | | Version | Comments |
|---|---|---|---|---|---|---|---|
| C520 | | 9/12/2011 | | 2013 C520 futuring V44.xls | | 44 | Tire data subject to change |
| | | | | | | | updated parasitics, new track coast down |
| C520 | | 2/17/2012 | | | | 44 | New Tieback process |

| Vehicle Description | | | | | | Single Roll Settings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | 3 Term coefs | | |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| C520 1.6 | All | Auto | FWD | P235/55R17 | 3750 | 13.0 | 17.91 | 21.18 | 0.4050 | 0.02232 |
| | | | | | 3875 | 13.1 | 18.36 | 21.88 | 0.4055 | 0.02233 |
| | | | | | 4000 | 13.2 | 18.81 | 22.59 | 0.4060 | 0.02234 |
| | | | | | 3875 | 14.2 | 16.94 | 24.22 | 0.4152 | 0.02449 |
| | | | | | 4000 | 14.3 | 17.36 | 24.93 | 0.4157 | 0.02450 |
| | | | | | 4250 | 14.5 | 18.18 | 26.36 | 0.4168 | 0.02453 |
| | | | | P235/50R18 | 3750 | 14.2 | 16.39 | 23.58 | 0.4297 | 0.02447 |
| | | | | | 3875 | 14.3 | 16.81 | 24.30 | 0.4308 | 0.02448 |
| | | | | | 4000 | 14.4 | 17.22 | 25.01 | 0.4318 | 0.02449 |
| | | | | | 4250 | 14.6 | 18.03 | 26.43 | 0.4340 | 0.02451 |
| | | | | P235/45R19 | 3750 | 14.1 | 16.46 | 23.65 | 0.4165 | 0.02453 |
| | | | | | 3875 | 14.2 | 16.88 | 24.39 | 0.4172 | 0.02454 |
| | | | | | 4000 | 14.3 | 17.29 | 25.13 | 0.4179 | 0.02455 |
| | | | | | 4250 | 14.5 | 18.09 | 26.62 | 0.4193 | 0.02458 |



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## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 Expedition*

| Coverage Chart | Date | RDM file | Comments |
|---|---|---|---|
| 13U222_chart.1_xls | 10/10/2011 | 11U222RDMVer43_4x2/4x4_4.xls | C/O 2011 MY |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| Expedition | 5.4L | Auto | 4x2 | P 265 70R 17 AS | 6000 | 20.2 | 18.40 | 40.86 | 0.4609 | 0.03496 |
| | | | | | 6500 | 20.7 | 19.41 | 44.09 | 0.4792 | 0.03491 |
| | | | | | 7000 | 21.2 | 20.37 | 47.32 | 0.4975 | 0.03486 |
| | | | | P 265 70R 17 AT | 6000 | 20.2 | 18.40 | 40.86 | 0.4609 | 0.03496 |
| | | | | | 6500 | 20.7 | 19.41 | 44.09 | 0.4792 | 0.03491 |
| | | | | | 7000 | 21.2 | 20.37 | 47.32 | 0.4975 | 0.03486 |
| | | | | P 255 70R 18 | 6000 | 21.5 | 17.25 | 52.60 | 0.3696 | 0.03606 |
| | | | | | 6500 | 22.1 | 18.17 | 56.57 | 0.3799 | 0.03610 |
| | | | | | 7000 | 22.7 | 19.04 | 60.53 | 0.3901 | 0.03614 |
| | | | | P 275 65R 18 | 6000 | 19.9 | 18.61 | 41.49 | 0.3533 | 0.03618 |
| | | | | | 6500 | 20.5 | 19.59 | 45.09 | 0.3638 | 0.03624 |
| | | | | | 7000 | 21.1 | 20.53 | 48.72 | 0.3744 | 0.03629 |
| | | | | P 275 55R 20 BSW | 6000 | 21.2 | 17.54 | 50.25 | 0.3719 | 0.03593 |
| | | | | | 6500 | 21.8 | 18.40 | 54.64 | 0.3838 | 0.03597 |
| | | | | | 7000 | 22.5 | 19.21 | 59.07 | 0.3958 | 0.03601 |
| | | | | P 275 55R 20 OWL | 6000 | 20.9 | 17.79 | 50.13 | 0.3184 | 0.03615 |
| | | | | | 6500 | 21.5 | 18.72 | 54.28 | 0.3249 | 0.03620 |
| | | | | | 7000 | 22.1 | 19.59 | 58.44 | 0.3314 | 0.03626 |
| Expedition Long | 5.4L | Auto | 4x2 | P 265 70R 17 AS | 6000 | 20.6 | 17.99 | 40.86 | 0.4609 | 0.03635 |
| | | | | | 6500 | 21.2 | 18.99 | 44.09 | 0.4792 | 0.03630 |
| | | | | | 7000 | 21.7 | 19.94 | 47.32 | 0.4975 | 0.03625 |
| | | | | P 265 70R 17 AT | 6000 | 20.6 | 17.99 | 40.86 | 0.4609 | 0.03635 |
| | | | | | 6500 | 21.2 | 18.99 | 44.09 | 0.4792 | 0.03630 |
| | | | | | 7000 | 21.7 | 19.94 | 47.32 | 0.4975 | 0.03625 |
| | | | | P 255 70R 18 | 6000 | 22.0 | 16.89 | 52.60 | 0.3696 | 0.03746 |
| | | | | | 6500 | 22.6 | 17.80 | 56.57 | 0.3799 | 0.03750 |
| | | | | | 7000 | 23.2 | 18.66 | 60.53 | 0.3901 | 0.03753 |
| | | | | P 275 65R 18 | 6000 | 20.4 | 18.19 | 41.49 | 0.3533 | 0.03757 |
| | | | | | 6500 | 21.0 | 19.16 | 45.09 | 0.3638 | 0.03763 |
| | | | | | 7000 | 21.6 | 20.08 | 48.72 | 0.3744 | 0.03769 |
| | | | | P 275 55R 20 BSW | 6000 | 21.6 | 17.16 | 50.25 | 0.3719 | 0.03733 |
| | | | | | 6500 | 22.3 | 18.02 | 54.64 | 0.3838 | 0.03736 |
| | | | | | 7000 | 23.0 | 18.83 | 59.07 | 0.3958 | 0.03740 |
| | | | | P 275 55R 20 OWL | 6000 | 21.3 | 17.40 | 50.13 | 0.3184 | 0.03754 |
| | | | | | 6500 | 21.9 | 18.32 | 54.28 | 0.3249 | 0.03760 |
| | | | | | 7000 | 22.6 | 19.19 | 58.44 | 0.3314 | 0.03765 |
| Expedition Limo | 5.4L | Auto | 4x2 | P 255 70R 18 | 8500 | 24.9 | 21.12 | 71.45 | 0.4183 | 0.03764 |
| | | | | | 9000 | 25.5 | 21.84 | 75.31 | 0.4282 | 0.03768 |
| | | | | | 9500 | 26.0 | 22.53 | 79.16 | 0.4382 | 0.03772 |
| | | | | P 275 65R 18 | 8500 | 23.3 | 22.55 | 59.80 | 0.4067 | 0.03786 |
| | | | | | 9000 | 23.9 | 23.28 | 63.54 | 0.4177 | 0.03792 |
| | | | | | 9500 | 24.5 | 23.97 | 67.31 | 0.4287 | 0.03798 |
| | | | | XL 285 60R 18 | 8500 | 24.1 | 21.81 | 68.87 | 0.3923 | 0.03683 |
| | | | | | 9000 | 24.6 | 22.58 | 72.61 | 0.4002 | 0.03682 |
| | | | | | 9500 | 25.2 | 23.31 | 76.35 | 0.4082 | 0.03682 |
| Expedition | 5.4L | Auto | 4x4 | P 265 70R 17 AS | 6000 | 22.3 | 16.61 | 48.21 | 0.8775 | 0.03013 |
| | | | | | 6500 | 22.9 | 17.58 | 51.43 | 0.8959 | 0.03008 |
| | | | | | 7000 | 23.4 | 18.49 | 54.66 | 0.9142 | 0.03004 |
| | | | | P 265 70R 17 AT | 6000 | 22.3 | 16.61 | 48.21 | 0.8775 | 0.03013 |
| | | | | | 6500 | 22.9 | 17.58 | 51.43 | 0.8959 | 0.03008 |
| | | | | | 7000 | 23.4 | 18.49 | 54.66 | 0.9142 | 0.03004 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 Expedition***

| Coverage Chart | Date | RDM file | Comments |
|---|---|---|---|
| 13U222_chart.1_xls | 10/10/2011 | 11U222RDMVer43_4x2/4x4_4.xls | C/O 2011 MY |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | P 255 70R 18 | 6000 | 23.6 | 15.69 | 59.93 | 0.7830 | 0.03126 |
| | | | | | 6500 | 24.2 | 16.56 | 63.90 | 0.7932 | 0.03130 |
| | | | | | 7000 | 24.9 | 17.40 | 67.86 | 0.8035 | 0.03134 |
| | | | | P 275 65R 18 | 6000 | 22.1 | 16.80 | 48.82 | 0.7665 | 0.03138 |
| | | | | | 6500 | 22.6 | 17.74 | 52.42 | 0.7770 | 0.03144 |
| | | | | | 7000 | 23.2 | 18.63 | 56.05 | 0.7876 | 0.03150 |
| | | | | P 275 55R 20 BSW | 6000 | 23.3 | 15.91 | 57.59 | 0.7863 | 0.03113 |
| | | | | | 6500 | 24.0 | 16.75 | 61.98 | 0.7982 | 0.03116 |
| | | | | | 7000 | 24.7 | 17.54 | 66.41 | 0.8102 | 0.03120 |
| | | | | P 275 55R 20 OWL | 6000 | 23.0 | 16.12 | 57.46 | 0.7328 | 0.03134 |
| | | | | | 6500 | 23.6 | 17.01 | 61.61 | 0.7393 | 0.03140 |
| | | | | | 7000 | 24.2 | 17.85 | 65.78 | 0.7458 | 0.03145 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 Expedition***

| Coverage Chart | Date | RDM file | Comments |
|---|---|---|---|
| 13U222_chart.1_xls | 10/10/2011 | 11U222RDMVer43_4x2/4x4_4.xls | C/O 2011 MY |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| Expedition Long | 5.4L | Auto | 4x4 | P 265 70R 17 AS | 6000 | 22.5 | 16.46 | 48.21 | 0.8775 | 0.03075 |
| | | | | | 6500 | 23.1 | 17.42 | 51.43 | 0.8959 | 0.03071 |
| | | | | | 7000 | 23.6 | 18.33 | 54.66 | 0.9142 | 0.03066 |
| | | | | P 265 70R 17 AT | 6000 | 22.5 | 16.46 | 48.21 | 0.8775 | 0.03075 |
| | | | | | 6500 | 23.1 | 17.42 | 51.43 | 0.8959 | 0.03071 |
| | | | | | 7000 | 23.6 | 18.33 | 54.66 | 0.9142 | 0.03066 |
| | | | | P 255 70R 18 | 6000 | 23.8 | 15.55 | 59.93 | 0.7830 | 0.03189 |
| | | | | | 6500 | 24.5 | 16.42 | 63.90 | 0.7932 | 0.03193 |
| | | | | | 7000 | 25.1 | 17.25 | 67.86 | 0.8035 | 0.03197 |
| | | | | P 275 65R 18 | 6000 | 22.3 | 16.64 | 48.82 | 0.7665 | 0.03200 |
| | | | | | 6500 | 22.9 | 17.58 | 52.42 | 0.7770 | 0.03206 |
| | | | | | 7000 | 23.4 | 18.46 | 56.05 | 0.7876 | 0.03212 |
| | | | | P 275 55R 20 BSW | 6000 | 23.5 | 15.77 | 57.59 | 0.7863 | 0.03175 |
| | | | | | 6500 | 24.2 | 16.61 | 61.98 | 0.7982 | 0.03179 |
| | | | | | 7000 | 24.9 | 17.39 | 66.41 | 0.8102 | 0.03182 |
| | | | | P 275 55R 20 OWL | 6000 | 23.2 | 15.98 | 57.46 | 0.7328 | 0.03197 |
| | | | | | 6500 | 23.8 | 16.86 | 61.61 | 0.7393 | 0.03202 |
| | | | | | 7000 | 24.4 | 17.70 | 65.78 | 0.7458 | 0.03207 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 U502*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 U502 TRLHP Chart_1 | 6/30/2011 | 2013 3.5L FWD U502_rdm1 V43C_jjw | 43 | Target .348 Cd FWD |
| | | 2013 2.0L FWD GTDI U502_rdm1 V43 | 43 | Target .338 Cd FWD GTDI |
| | | | | Full new track benefit |
| 2013 U502 TRLHP Chart_1 | 7/21/2011 | 2013 3.5L FWD U502_rdm1 V43C_jjw | 43 | Gen II 18" tire change from |
| | | 2013 2.0L FWD GTDI U502_rdm1 V43 | 43 | 7.2 to 7.3 RRC |
| 2013 U502 TRLHP Chart_1 | 1/24/2012 | 2013 2.0L FWD GTDI U502_rdm1 V43 | 43 | Added 17" GDY & 20" HK Tires |

| Vehicle Description | | | | | | | | Track Coefficients 3 - Term | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| U502 FWD | 3.5L | Auto | FWD | P 245 65R 17 | 4500 | 15.3 | 18.16 | 31.72 | 0.3507 | 0.02627 |
| | | | | | 4750 | 15.6 | 18.78 | 33.70 | 0.3583 | 0.02628 |
| | | | | | 5000 | 16.0 | 19.37 | 35.70 | 0.3660 | 0.02629 |
| | | | | | 5250 | 16.3 | 19.94 | 37.69 | 0.3736 | 0.02629 |
| | | | | | 5500 | 16.6 | 20.48 | 39.69 | 0.3812 | 0.02630 |
| | | | | P 245 60R 18 | 4500 | 15.1 | 18.42 | 30.08 | 0.3279 | 0.02676 |
| | | | | | 4750 | 15.4 | 19.03 | 32.07 | 0.3345 | 0.02680 |
| | | | | | 5000 | 15.8 | 19.62 | 34.06 | 0.3411 | 0.02684 |
| | | | | | 5250 | 16.1 | 20.18 | 36.07 | 0.3478 | 0.02688 |
| | | | | | 5500 | 16.4 | 20.72 | 38.09 | 0.3545 | 0.02692 |
| | | | | P 255 50R 20 | 4500 | 15.4 | 18.11 | 31.98 | 0.3937 | 0.02543 |
| | | | | | 4750 | 15.7 | 18.73 | 33.94 | 0.4040 | 0.02538 |
| | | | | | 5000 | 16.0 | 19.33 | 35.89 | 0.4144 | 0.02533 |
| | | | | | 5250 | 16.3 | 19.90 | 37.84 | 0.4248 | 0.02529 |
| | | | | | 5500 | 16.6 | 20.45 | 39.80 | 0.4351 | 0.02524 |
| U502 GTDI | 2.0L | Auto | FWD | P 245 65R 17 | 4500 | 15.1 | 18.47 | 29.64 | 0.2894 | 0.02758 |
| | | | | | 4750 | 15.4 | 19.09 | 31.63 | 0.2970 | 0.02759 |
| | | | | | 5000 | 15.7 | 19.68 | 33.62 | 0.3047 | 0.02760 |
| | | | | | 5250 | 16.0 | 20.25 | 35.62 | 0.3123 | 0.02760 |
| | | | | | 5500 | 16.4 | 20.80 | 37.62 | 0.3199 | 0.02761 |
| | | | | P 245 60R 18 | 4500 | 14.1 | 19.70 | 23.45 | 0.2595 | 0.02787 |
| | | | | | 4750 | 14.4 | 20.40 | 25.08 | 0.2654 | 0.02790 |
| | | | | | 5000 | 14.7 | 21.08 | 26.72 | 0.2713 | 0.02792 |
| | | | | | 5250 | 14.9 | 21.74 | 28.37 | 0.2773 | 0.02795 |
| | | | | | 5500 | 15.2 | 22.37 | 30.02 | 0.2832 | 0.02797 |
| | | | | P 245 50R 20 | 4500 | 16.2 | 17.20 | 38.49 | 0.2836 | 0.02745 |
| | | | | | 4750 | 16.5 | 17.77 | 40.81 | 0.2904 | 0.02745 |
| | | | | | 5000 | 16.9 | 18.31 | 43.11 | 0.2971 | 0.02745 |
| | | | | | 5250 | 17.2 | 18.83 | 45.42 | 0.3038 | 0.02744 |
| | | | | | 5500 | 17.6 | 19.33 | 47.72 | 0.3105 | 0.02744 |
| | | | | P 255 50R 20 | 4500 | 15.1 | 18.41 | 29.97 | 0.3313 | 0.02674 |
| | | | | | 4750 | 15.4 | 19.04 | 31.93 | 0.3416 | 0.02669 |
| | | | | | 5000 | 15.7 | 19.64 | 33.88 | 0.3520 | 0.02665 |
| | | | | | 5250 | 16.1 | 20.21 | 35.84 | 0.3623 | 0.02660 |
| | | | | | 5500 | 16.4 | 20.77 | 37.79 | 0.3727 | 0.02655 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 U502*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 U502 TRLHP Chart_1 | 6/30/2011 | 2013 3.5L AWD U502_rdm1 V43 ( | 43 | AWD 3.5L Target .350 Cd<br>Full new track benefit |

| Vehicle Description | | | | | | | | Track Coefficients 3 - Term | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| U502 AWD | 3.5L | Auto | AWD | P 245 65R 17 | 4500 | 17.3 | 16.09 | 31.98 | 0.7882 | 0.02332 |
| | | | | | 4750 | 17.6 | 16.67 | 33.97 | 0.7958 | 0.02333 |
| | | | | | 5000 | 17.9 | 17.24 | 35.96 | 0.8035 | 0.02334 |
| | | | | | 5250 | 18.2 | 17.78 | 37.96 | 0.8111 | 0.02334 |
| | | | | | 5500 | 18.6 | 18.31 | 39.96 | 0.8187 | 0.02335 |
| | | | | P 245 60R 18 | 4500 | 17.1 | 16.29 | 30.35 | 0.7648 | 0.02382 |
| | | | | | 4750 | 17.4 | 16.87 | 32.33 | 0.7713 | 0.02386 |
| | | | | | 5000 | 17.7 | 17.43 | 34.33 | 0.7780 | 0.02390 |
| | | | | | 5250 | 18.1 | 17.97 | 36.34 | 0.7846 | 0.02394 |
| | | | | | 5500 | 18.4 | 18.49 | 38.35 | 0.7913 | 0.02398 |
| | | | | P 255 50R 20 | 4500 | 17.3 | 16.06 | 32.28 | 0.8218 | 0.02262 |
| | | | | | 4750 | 17.6 | 16.65 | 34.23 | 0.8321 | 0.02258 |
| | | | | | 5000 | 18.0 | 17.22 | 36.19 | 0.8425 | 0.02253 |
| | | | | | 5250 | 18.3 | 17.77 | 38.14 | 0.8529 | 0.02248 |
| | | | | | 5500 | 18.6 | 18.29 | 40.10 | 0.8632 | 0.02244 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013.5 U502*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 U502 TRLHP Chart_1 | 7/27/2011 | 2013.5 3.5L AWD U502 GTDI SPORT | 43 | |
| 2013 U502 TRLHP Chart_1 | 5/24/2012 | 2013.5 3.5L AWD U502 GTDI SPORT | 43 | Deleted 20" Sport Tire<br>Added new 20" Summer Tire |

| Vehicle Description | | | | | | 3-Term | | Track Coefficients 3 Term coefs | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| U502 AWD GTDI SPORT | 3.5L | Auto | AWD | P 245 65R 17 | 4500 | 17.5 | 15.92 | 31.98 | 0.7879 | 0.02389 |
| | | | | | 4750 | 17.8 | 16.50 | 33.97 | 0.7955 | 0.02390 |
| | | | | | 5000 | 18.1 | 17.06 | 35.96 | 0.8031 | 0.02390 |
| | | | | | 5250 | 18.4 | 17.60 | 37.96 | 0.8108 | 0.02391 |
| | | | | | 5500 | 18.8 | 18.12 | 39.96 | 0.8184 | 0.02392 |
| | | | | P 245 60R 18 | 4500 | 17.3 | 16.11 | 30.34 | 0.7648 | 0.02438 |
| | | | | | 4750 | 17.6 | 16.70 | 32.33 | 0.7713 | 0.02442 |
| | | | | | 5000 | 17.9 | 17.25 | 34.33 | 0.7779 | 0.02446 |
| | | | | | 5250 | 18.2 | 17.79 | 36.33 | 0.7846 | 0.02450 |
| | | | | | 5500 | 18.6 | 18.31 | 38.35 | 0.7913 | 0.02454 |
| | | | | P 255 50R 20 (Non Sport Tire) | 4500 | 17.5 | 15.90 | 32.27 | 0.8261 | 0.02305 |
| | | | | | 4750 | 17.8 | 16.49 | 34.22 | 0.8364 | 0.02300 |
| | | | | | 5000 | 18.1 | 17.05 | 36.18 | 0.8468 | 0.02296 |
| | | | | | 5250 | 18.4 | 17.60 | 38.13 | 0.8571 | 0.02291 |
| | | | | | 5500 | 18.7 | 18.13 | 40.09 | 0.8675 | 0.02286 |
| | | | | 265 45ZR 20 (Summer Tire) | 4500 | 18.1 | 15.41 | 37.39 | 0.7740 | 0.02372 |
| | | | | | 4750 | 18.4 | 15.97 | 39.58 | 0.7801 | 0.02372 |
| | | | | | 5000 | 18.7 | 16.51 | 41.77 | 0.7863 | 0.02371 |
| | | | | | 5250 | 19.0 | 17.03 | 43.96 | 0.7925 | 0.02371 |
| | | | | | 5500 | 19.4 | 17.53 | 46.15 | 0.7987 | 0.02371 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 U502 Police*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 2013 U502 TRLHP Chart_1 | 6/30/2011 | 2013 Police FWD U502_rdm | 43 | Target .380 Cd, 32.75 FA |
| | | 2013 Police AWD U502_rdm | 43 | Full new track benefit |

| Vehicle Description | | | | | | | | Track Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | f0 | f1 | f2 |
| U502 FWD | All | Auto | FWD | 245 55R 18 | 4500 | 17.8 | 15.64 | 40.01 | 0.4566 | 0.02822 |
| | | | | | 4750 | 18.2 | 16.16 | 42.50 | 0.4643 | 0.02823 |
| | | | | | 5000 | 18.6 | 16.65 | 44.99 | 0.4719 | 0.02824 |
| | | | | | 5250 | 18.9 | 17.13 | 47.49 | 0.4796 | 0.02825 |
| | | | | | 5500 | 19.3 | 17.58 | 49.98 | 0.4873 | 0.02826 |
| U502 AWD | All | Auto | AWD | 245 55R 18 | 4500 | 19.2 | 14.48 | 46.49 | 0.6804 | 0.02539 |
| | | | | | 4750 | 19.6 | 14.98 | 48.98 | 0.6881 | 0.02540 |
| | | | | | 5000 | 20.0 | 15.47 | 51.48 | 0.6957 | 0.02541 |
| | | | | | 5250 | 20.4 | 15.93 | 53.97 | 0.7034 | 0.02542 |
| | | | | | 5500 | 20.7 | 16.37 | 56.47 | 0.7111 | 0.02543 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 GTDi***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart1.xls | 3/12/2012 | 12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_GTDi_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| F150 RCL | 3.5L GTDI | Auto | 4x2 | P 235 75R 17 | 5000 | 19.1 | 16.23 | 30.03 | 0.2722 | 0.03977 |
| | | | | | 5250 | 19.3 | 16.84 | 31.41 | 0.2776 | 0.03980 |
| | | | | | 5500 | 19.5 | 17.43 | 32.79 | 0.2830 | 0.03983 |
| | | | | | 6000 | 20.0 | 18.58 | 35.54 | 0.2938 | 0.03989 |
| | | | | | 6500 | 20.5 | 19.67 | 38.30 | 0.3046 | 0.03995 |
| | | | | P 255 65R 17 | 5000 | 20.1 | 15.38 | 36.71 | 0.2885 | 0.03990 |
| | | | | | 5250 | 20.4 | 15.93 | 38.43 | 0.2944 | 0.03995 |
| | | | | | 5500 | 20.7 | 16.46 | 40.14 | 0.3002 | 0.03999 |
| | | | | | 6000 | 21.2 | 17.47 | 43.57 | 0.3118 | 0.04007 |
| | | | | | 6500 | 21.8 | 18.44 | 47.01 | 0.3235 | 0.04016 |
| | | | | LT 275 65R 18 | 5000 | 22.1 | 14.00 | 51.69 | 0.2526 | 0.04055 |
| | | | | | 5250 | 22.5 | 14.46 | 54.05 | 0.2572 | 0.04061 |
| | | | | | 5500 | 22.8 | 14.90 | 56.41 | 0.2619 | 0.04068 |
| | | | | | 6000 | 23.6 | 15.75 | 61.11 | 0.2710 | 0.04080 |
| | | | | | 6500 | 24.3 | 16.55 | 65.78 | 0.2802 | 0.04092 |
| | | | | LT 245 75R 17 | 5000 | 20.7 | 14.96 | 43.04 | 0.2506 | 0.03979 |
| | | | | | 5250 | 21.0 | 15.49 | 44.99 | 0.2549 | 0.03982 |
| | | | | | 5500 | 21.3 | 16.00 | 46.94 | 0.2592 | 0.03985 |
| | | | | | 6000 | 21.9 | 16.97 | 50.82 | 0.2677 | 0.03990 |
| | | | | | 6500 | 22.4 | 17.90 | 54.68 | 0.2763 | 0.03995 |
| | | | | P 265 60R 18 | 5000 | 19.6 | 15.82 | 33.39 | 0.2983 | 0.03937 |
| | | | | | 5250 | 19.8 | 16.39 | 35.05 | 0.3053 | 0.03938 |
| | | | | | 5500 | 20.1 | 16.93 | 36.71 | 0.3123 | 0.03939 |
| | | | | | 6000 | 20.7 | 17.98 | 40.04 | 0.3265 | 0.03941 |
| | | | | | 6500 | 21.2 | 18.96 | 43.41 | 0.3408 | 0.03944 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5000 | 20.2 | 15.30 | 41.27 | 0.2186 | 0.03978 |
| | | | | | 5250 | 20.5 | 15.83 | 43.33 | 0.2218 | 0.03981 |
| | | | | | 5500 | 20.8 | 16.34 | 45.39 | 0.2250 | 0.03983 |
| | | | | | 6000 | 21.4 | 17.31 | 49.52 | 0.2314 | 0.03989 |
| | | | | | 6500 | 22.1 | 18.22 | 53.68 | 0.2379 | 0.03994 |
| | | | | P 275 55R 20 BSW | 5000 | 20.5 | 15.09 | 41.62 | 0.2631 | 0.03961 |
| | | | | | 5250 | 20.8 | 15.58 | 43.81 | 0.2691 | 0.03962 |
| | | | | | 5500 | 21.2 | 16.06 | 46.01 | 0.2750 | 0.03964 |
| | | | | | 6000 | 21.9 | 16.97 | 50.44 | 0.2870 | 0.03968 |
| | | | | | 6500 | 22.6 | 17.82 | 54.91 | 0.2992 | 0.03972 |
| | | | | P 265 70R 17 | 5000 | 20.1 | 15.37 | 37.03 | 0.2760 | 0.04009 |
| | | | | | 5250 | 20.4 | 15.91 | 38.79 | 0.2820 | 0.04013 |
| | | | | | 5500 | 20.7 | 16.43 | 40.55 | 0.2880 | 0.04017 |
| | | | | | 6000 | 21.3 | 17.43 | 44.08 | 0.2999 | 0.04026 |
| | | | | | 6500 | 21.9 | 18.38 | 47.62 | 0.3119 | 0.04035 |
| | | | | P 275 45R 22 | 5000 | 21.8 | 14.16 | 48.48 | 0.3312 | 0.03950 |
| | | | | | 5250 | 22.2 | 14.65 | 50.50 | 0.3388 | 0.03951 |
| | | | | | 5500 | 22.5 | 15.13 | 52.51 | 0.3464 | 0.03952 |
| | | | | | 6000 | 23.1 | 16.04 | 56.50 | 0.3615 | 0.03954 |
| | | | | | 6500 | 23.8 | 16.91 | 60.44 | 0.3764 | 0.03956 |
| | | | | P 275 65R 18 | 5000 | 19.4 | 15.99 | 33.45 | 0.2461 | 0.03979 |
| | | | | | 5250 | 19.6 | 16.55 | 35.19 | 0.2512 | 0.03982 |
| | | | | | 5500 | 19.9 | 17.10 | 36.94 | 0.2563 | 0.03984 |
| | | | | | 6000 | 20.5 | 18.14 | 40.47 | 0.2667 | 0.03990 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

**2013 F150 GTDi**

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| **13P415_chart3.xls** | **7/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **Add new 20" tire** |
| **13P415_chart1.xls** | **3/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **New Track** |
| **13P415_chart.xls** | **10/12/2011** | **12P415_GTDi_4x2/4x4.RDMVer43.xls** | **43** | **Carryover 2012** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 6500 | 21.0 | 19.12 | 44.03 | 0.2771 | 0.03996 |
| F150 All SC except 163" WE | 3.5L GTDI | Auto | 4x2 | P 235 75R 17 | 5250 | 18.9 | 17.21 | 31.41 | 0.2776 | 0.03857 |
| | | | | | 5500 | 19.1 | 17.81 | 32.79 | 0.2830 | 0.03860 |
| | | | | | 6000 | 19.6 | 18.97 | 35.54 | 0.2938 | 0.03866 |
| | | | | | 6500 | 20.0 | 20.07 | 38.30 | 0.3046 | 0.03872 |
| | | | | | 7000 | 20.5 | 21.12 | 41.07 | 0.3154 | 0.03878 |
| | | | | P 255 65R 17 | 5250 | 20.0 | 16.25 | 38.43 | 0.2944 | 0.03872 |
| | | | | | 5500 | 20.3 | 16.79 | 40.14 | 0.3002 | 0.03876 |
| | | | | | 6000 | 20.8 | 17.81 | 43.57 | 0.3118 | 0.03885 |
| | | | | | 6500 | 21.4 | 18.79 | 47.01 | 0.3235 | 0.03893 |
| | | | | | 7000 | 22.0 | 19.71 | 50.45 | 0.3352 | 0.03902 |
| | | | | LT 275 65R 18 | 5250 | 22.1 | 14.72 | 54.05 | 0.2572 | 0.03939 |
| | | | | | 5500 | 22.4 | 15.17 | 56.41 | 0.2619 | 0.03945 |
| | | | | | 6000 | 23.1 | 16.02 | 61.11 | 0.2710 | 0.03957 |
| | | | | | 6500 | 23.9 | 16.83 | 65.78 | 0.2802 | 0.03969 |
| | | | | | 7000 | 24.6 | 17.59 | 70.44 | 0.2893 | 0.03981 |
| | | | | LT 245 75R 17 | 5250 | 20.6 | 15.79 | 44.99 | 0.2549 | 0.03860 |
| | | | | | 5500 | 20.9 | 16.31 | 46.94 | 0.2592 | 0.03862 |
| | | | | | 6000 | 21.5 | 17.29 | 50.82 | 0.2677 | 0.03868 |
| | | | | | 6500 | 22.0 | 18.23 | 54.68 | 0.2763 | 0.03873 |
| | | | | | 7000 | 22.6 | 19.12 | 58.53 | 0.2848 | 0.03878 |
| | | | | P 265 60R 18 | 5250 | 19.4 | 16.73 | 35.05 | 0.3053 | 0.03815 |
| | | | | | 5500 | 19.7 | 17.28 | 36.71 | 0.3123 | 0.03816 |
| | | | | | 6000 | 20.2 | 18.34 | 40.04 | 0.3265 | 0.03819 |
| | | | | | 6500 | 20.8 | 19.34 | 43.41 | 0.3408 | 0.03821 |
| | | | | | 7000 | 21.4 | 20.28 | 46.79 | 0.3552 | 0.03824 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 GTDi***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| **13P415_chart3.xls** | **7/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **Add new 20" tire** |
| **13P415_chart1.xls** | **3/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **New Track** |
| **13P415_chart.xls** | **10/12/2011** | **12P415_GTDi_4x2/4x4.RDMVer43.xls** | **43** | **Carryover 2012** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5250 | 20.1 | 16.15 | 43.33 | 0.2218 | 0.03858 |
| | | | | | 5500 | 20.4 | 16.66 | 45.39 | 0.2250 | 0.03861 |
| | | | | | 6000 | 21.0 | 17.64 | 49.52 | 0.2314 | 0.03866 |
| | | | | | 6500 | 21.6 | 18.56 | 53.68 | 0.2379 | 0.03872 |
| | | | | | 7000 | 22.3 | 19.44 | 57.85 | 0.2444 | 0.03877 |
| | | | | P 275 55R 20 BSW | 5250 | 20.4 | 15.89 | 43.81 | 0.2691 | 0.03840 |
| | | | | | 5500 | 20.8 | 16.38 | 46.01 | 0.2750 | 0.03842 |
| | | | | | 6000 | 21.5 | 17.29 | 50.44 | 0.2870 | 0.03845 |
| | | | | | 6500 | 22.1 | 18.15 | 54.91 | 0.2992 | 0.03849 |
| | | | | | 7000 | 22.8 | 18.94 | 59.42 | 0.3114 | 0.03853 |
| | | | | P 265 70R 17 | 5250 | 20.0 | 16.23 | 38.79 | 0.2820 | 0.03890 |
| | | | | | 5500 | 20.3 | 16.76 | 40.55 | 0.2880 | 0.03895 |
| | | | | | 6000 | 20.9 | 17.77 | 44.08 | 0.2999 | 0.03903 |
| | | | | | 6500 | 21.5 | 18.73 | 47.62 | 0.3119 | 0.03912 |
| | | | | | 7000 | 22.1 | 19.63 | 51.16 | 0.3239 | 0.03921 |
| | | | | P 275 45R 22 | 5250 | 21.8 | 14.92 | 50.50 | 0.3388 | 0.03828 |
| | | | | | 5500 | 22.1 | 15.41 | 52.51 | 0.3464 | 0.03829 |
| | | | | | 6000 | 22.7 | 16.33 | 56.50 | 0.3615 | 0.03831 |
| | | | | | 6500 | 23.3 | 17.21 | 60.44 | 0.3764 | 0.03833 |
| | | | | | 7000 | 24.0 | 18.05 | 64.35 | 0.3911 | 0.03835 |
| | | | | P 275 65R 18 | 5250 | 19.2 | 16.90 | 35.19 | 0.2512 | 0.03859 |
| | | | | | 5500 | 19.5 | 17.45 | 36.94 | 0.2563 | 0.03862 |
| | | | | | 6000 | 20.1 | 18.51 | 40.47 | 0.2667 | 0.03867 |
| | | | | | 6500 | 20.6 | 19.49 | 44.03 | 0.2771 | 0.03873 |
| | | | | | 7000 | 21.2 | 20.43 | 47.63 | 0.2876 | 0.03879 |
| F150 SC w/163" WB | 3.5L GTDI | Auto | 4x2 | P 235 75R 17 | 5250 | 19.2 | 16.97 | 31.41 | 0.2776 | 0.03936 |
| | | | | | 5500 | 19.4 | 17.56 | 32.79 | 0.2830 | 0.03939 |
| | | | | | 6000 | 19.8 | 18.71 | 35.54 | 0.2938 | 0.03945 |
| | | | | | 6500 | 20.3 | 19.81 | 38.30 | 0.3046 | 0.03951 |
| | | | | | 7000 | 20.8 | 20.86 | 41.07 | 0.3154 | 0.03957 |
| | | | | P 255 65R 17 | 5250 | 20.3 | 16.04 | 38.43 | 0.2944 | 0.03951 |
| | | | | | 5500 | 20.5 | 16.57 | 40.14 | 0.3002 | 0.03955 |
| | | | | | 6000 | 21.1 | 17.60 | 43.57 | 0.3118 | 0.03963 |
| | | | | | 6500 | 21.7 | 18.56 | 47.01 | 0.3235 | 0.03972 |
| | | | | | 7000 | 22.2 | 19.48 | 50.45 | 0.3352 | 0.03980 |
| | | | | LT 275 65R 18 | 5250 | 22.3 | 14.55 | 54.05 | 0.2572 | 0.04018 |
| | | | | | 5500 | 22.7 | 14.99 | 56.41 | 0.2619 | 0.04024 |
| | | | | | 6000 | 23.4 | 15.84 | 61.11 | 0.2710 | 0.04036 |
| | | | | | 6500 | 24.1 | 16.65 | 65.78 | 0.2802 | 0.04048 |
| | | | | | 7000 | 24.9 | 17.40 | 70.44 | 0.2893 | 0.04060 |
| | | | | LT 245 75R 17 | 5250 | 20.8 | 15.60 | 44.99 | 0.2549 | 0.03938 |
| | | | | | 5500 | 21.1 | 16.11 | 46.94 | 0.2592 | 0.03941 |
| | | | | | 6000 | 21.7 | 17.09 | 50.82 | 0.2677 | 0.03946 |
| | | | | | 6500 | 22.3 | 18.02 | 54.68 | 0.2763 | 0.03952 |
| | | | | | 7000 | 22.9 | 18.90 | 58.53 | 0.2848 | 0.03957 |
| | | | | P 265 60R 18 | 5250 | 19.7 | 16.51 | 35.05 | 0.3053 | 0.03894 |
| | | | | | 5500 | 20.0 | 17.06 | 36.71 | 0.3123 | 0.03895 |
| | | | | | 6000 | 20.5 | 18.10 | 40.04 | 0.3265 | 0.03898 |
| | | | | | 6500 | 21.1 | 19.10 | 43.41 | 0.3408 | 0.03900 |
| | | | | | 7000 | 21.6 | 20.03 | 46.79 | 0.3552 | 0.03903 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5250 | 20.4 | 15.94 | 43.33 | 0.2218 | 0.03937 |
| | | | | | 5500 | 20.7 | 16.45 | 45.39 | 0.2250 | 0.03940 |
| | | | | | 6000 | 21.3 | 17.43 | 49.52 | 0.2314 | 0.03945 |
| | | | | | 6500 | 21.9 | 18.34 | 53.68 | 0.2379 | 0.03950 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

## *2013 F150 GTDi*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| **13P415_chart3.xls** | **7/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **Add new 20" tire** |
| **13P415_chart1.xls** | **3/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **New Track** |
| **13P415_chart.xls** | **10/12/2011** | **12P415_GTDi_4x2/4x4.RDMVer43.xls** | **43** | **Carryover 2012** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 7000 | 22.5 | 19.21 | 57.85 | 0.2444 | 0.03956 |
| | | | | P 275 55R 20 BSW | 5250 | 20.7 | 15.69 | 43.81 | 0.2691 | 0.03919 |
| | | | | | 5500 | 21.0 | 16.17 | 46.01 | 0.2750 | 0.03920 |
| | | | | | 6000 | 21.7 | 17.09 | 50.44 | 0.2870 | 0.03924 |
| | | | | | 6500 | 22.4 | 17.93 | 54.91 | 0.2992 | 0.03928 |
| | | | | | 7000 | 23.1 | 18.73 | 59.42 | 0.3114 | 0.03931 |
| | | | | P 265 70R 17 | 5250 | 20.3 | 16.02 | 38.79 | 0.2820 | 0.03969 |
| | | | | | 5500 | 20.6 | 16.54 | 40.55 | 0.2880 | 0.03974 |
| | | | | | 6000 | 21.2 | 17.55 | 44.08 | 0.2999 | 0.03982 |
| | | | | | 6500 | 21.7 | 18.50 | 47.62 | 0.3119 | 0.03991 |
| | | | | | 7000 | 22.3 | 19.40 | 51.16 | 0.3239 | 0.04000 |
| | | | | P 275 45R 22 | 5250 | 22.0 | 14.75 | 50.50 | 0.3388 | 0.03907 |
| | | | | | 5500 | 22.3 | 15.22 | 52.51 | 0.3464 | 0.03908 |
| | | | | | 6000 | 23.0 | 16.14 | 56.50 | 0.3615 | 0.03910 |
| | | | | | 6500 | 23.6 | 17.02 | 60.44 | 0.3764 | 0.03912 |
| | | | | | 7000 | 24.2 | 17.85 | 64.35 | 0.3911 | 0.03914 |
| | | | | P 275 65R 18 | 5250 | 19.5 | 16.67 | 35.19 | 0.2512 | 0.03938 |
| | | | | | 5500 | 19.8 | 17.22 | 36.94 | 0.2563 | 0.03941 |
| | | | | | 6000 | 20.3 | 18.27 | 40.47 | 0.2667 | 0.03946 |
| | | | | | 6500 | 20.9 | 19.25 | 44.03 | 0.2771 | 0.03952 |
| | | | | | 7000 | 21.5 | 20.18 | 47.63 | 0.2876 | 0.03958 |
| F150 CC-Short | 3.5L GTDI | Auto | 4x2 | P 235 75R 17 | 5500 | 18.8 | 18.07 | 32.79 | 0.2830 | 0.03776 |
| | | | | | 6000 | 19.3 | 19.24 | 35.54 | 0.2938 | 0.03782 |
| | | | | | 6500 | 19.8 | 20.35 | 38.30 | 0.3046 | 0.03788 |
| | | | | P 255 65R 17 | 5500 | 20.0 | 17.02 | 40.14 | 0.3002 | 0.03792 |
| | | | | | 6000 | 20.6 | 18.06 | 43.57 | 0.3118 | 0.03801 |
| | | | | | 6500 | 21.1 | 19.03 | 47.01 | 0.3235 | 0.03809 |
| | | | | LT 275 65R 18 | 5500 | 22.1 | 15.36 | 56.41 | 0.2619 | 0.03861 |
| | | | | | 6000 | 22.9 | 16.22 | 61.11 | 0.2710 | 0.03873 |
| | | | | | 6500 | 23.6 | 17.03 | 65.78 | 0.2802 | 0.03885 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

**2013 F150 GTDi**

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| **13P415_chart3.xls** | **7/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **Add new 20" tire** |
| **13P415_chart1.xls** | **3/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **New Track** |
| **13P415_chart.xls** | **10/12/2011** | **12P415_GTDi_4x2/4x4.RDMVer43.xls** | **43** | **Carryover 2012** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | LT 245 75R 17 | 5500 | 20.6 | 16.53 | 46.94 | 0.2592 | 0.03778 |
| | | | | | 6000 | 21.2 | 17.52 | 50.82 | 0.2677 | 0.03784 |
| | | | | | 6500 | 21.8 | 18.47 | 54.68 | 0.2763 | 0.03789 |
| | | | | P 265 60R 18 | 5500 | 19.4 | 17.53 | 36.71 | 0.3123 | 0.03733 |
| | | | | | 6000 | 20.0 | 18.60 | 40.04 | 0.3265 | 0.03735 |
| | | | | | 6500 | 20.5 | 19.60 | 43.41 | 0.3408 | 0.03737 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5500 | 20.1 | 16.89 | 45.39 | 0.2250 | 0.03777 |
| | | | | | 6000 | 20.8 | 17.88 | 49.52 | 0.2314 | 0.03782 |
| | | | | | 6500 | 21.4 | 18.81 | 53.68 | 0.2379 | 0.03788 |
| | | | | P 275 55R 20 BSW | 5500 | 20.5 | 16.60 | 46.01 | 0.2750 | 0.03758 |
| | | | | | 6000 | 21.2 | 17.52 | 50.44 | 0.2870 | 0.03761 |
| | | | | | 6500 | 21.9 | 18.38 | 54.91 | 0.2992 | 0.03765 |
| | | | | P 265 70R 17 | 5500 | 20.0 | 16.99 | 40.55 | 0.2880 | 0.03811 |
| | | | | | 6000 | 20.6 | 18.01 | 44.08 | 0.2999 | 0.03819 |
| | | | | | 6500 | 21.2 | 18.97 | 47.62 | 0.3119 | 0.03828 |
| | | | | P 275 45R 22 | 5500 | 21.8 | 15.60 | 52.51 | 0.3464 | 0.03745 |
| | | | | | 6000 | 22.4 | 16.53 | 56.50 | 0.3615 | 0.03747 |
| | | | | | 6500 | 23.1 | 17.42 | 60.44 | 0.3764 | 0.03749 |
| | | | | P 275 65R 18 | 5500 | 19.2 | 17.70 | 36.94 | 0.2563 | 0.03778 |
| | | | | | 6000 | 19.8 | 18.77 | 40.47 | 0.2667 | 0.03783 |
| | | | | | 6500 | 20.3 | 19.76 | 44.03 | 0.2771 | 0.03789 |
| F150 CC-Long | 3.5L GTDI | Auto | 4x2 | P 235 75R 17 | 5500 | 19.0 | 17.93 | 32.79 | 0.2830 | 0.03820 |
| | | | | | 6000 | 19.5 | 19.10 | 35.54 | 0.2938 | 0.03826 |
| | | | | | 6500 | 19.9 | 20.20 | 38.30 | 0.3046 | 0.03832 |
| | | | | P 255 65R 17 | 5500 | 20.1 | 16.90 | 40.14 | 0.3002 | 0.03836 |
| | | | | | 6000 | 20.7 | 17.93 | 43.57 | 0.3118 | 0.03845 |
| | | | | | 6500 | 21.3 | 18.90 | 47.01 | 0.3235 | 0.03853 |
| | | | | LT 275 65R 18 | 5500 | 22.3 | 15.26 | 56.41 | 0.2619 | 0.03905 |
| | | | | | 6000 | 23.0 | 16.12 | 61.11 | 0.2710 | 0.03917 |
| | | | | | 6500 | 23.7 | 16.92 | 65.78 | 0.2802 | 0.03929 |
| | | | | LT 245 75R 17 | 5500 | 20.7 | 16.41 | 46.94 | 0.2592 | 0.03822 |
| | | | | | 6000 | 21.3 | 17.40 | 50.82 | 0.2677 | 0.03828 |
| | | | | | 6500 | 21.9 | 18.34 | 54.68 | 0.2763 | 0.03833 |
| | | | | P 265 60R 18 | 5500 | 19.6 | 17.40 | 36.71 | 0.3123 | 0.03777 |
| | | | | | 6000 | 20.1 | 18.46 | 40.04 | 0.3265 | 0.03779 |
| | | | | | 6500 | 20.7 | 19.46 | 43.41 | 0.3408 | 0.03781 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5500 | 20.3 | 16.77 | 45.39 | 0.2250 | 0.03821 |
| | | | | | 6000 | 20.9 | 17.76 | 49.52 | 0.2314 | 0.03826 |
| | | | | | 6500 | 21.5 | 18.68 | 53.68 | 0.2379 | 0.03832 |
| | | | | P 275 55R 20 BSW | 5500 | 20.6 | 16.48 | 46.01 | 0.2750 | 0.03802 |
| | | | | | 6000 | 21.3 | 17.40 | 50.44 | 0.2870 | 0.03805 |
| | | | | | 6500 | 22.0 | 18.26 | 54.91 | 0.2992 | 0.03809 |
| | | | | P 265 70R 17 | 5500 | 20.2 | 16.87 | 40.55 | 0.2880 | 0.03855 |
| | | | | | 6000 | 20.8 | 17.89 | 44.08 | 0.2999 | 0.03863 |
| | | | | | 6500 | 21.3 | 18.84 | 47.62 | 0.3119 | 0.03872 |
| | | | | P 275 45R 22 | 5500 | 21.9 | 15.50 | 52.51 | 0.3464 | 0.03790 |
| | | | | | 6000 | 22.6 | 16.43 | 56.50 | 0.3615 | 0.03791 |
| | | | | | 6500 | 23.2 | 17.31 | 60.44 | 0.3764 | 0.03793 |
| | | | | P 275 65R 18 | 5500 | 19.4 | 17.57 | 36.94 | 0.2563 | 0.03822 |
| | | | | | 6000 | 19.9 | 18.63 | 40.47 | 0.2667 | 0.03827 |
| | | | | | 6500 | 20.5 | 19.62 | 44.03 | 0.2771 | 0.03833 |
| F150 RCL | 3.5L GTDI | Auto | 4x4 | P 235 75R 17 | 5250 | 20.5 | 15.83 | 32.25 | 0.3946 | 0.04081 |
| | | | | | 5500 | 20.8 | 16.40 | 33.62 | 0.4000 | 0.04084 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 GTDi***

| **Coverage Chart** | **Date** | **RDM file** | **Version** | **Comments** |
|---|---|---|---|---|
| **13P415_chart3.xls** | **7/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **Add new 20" tire** |
| **13P415_chart1.xls** | **3/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **New Track** |
| **13P415_chart.xls** | **10/12/2011** | **12P415_GTDi_4x2/4x4.RDMVer43.xls** | **43** | **Carryover 2012** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 6000 | 21.2 | 17.50 | 36.38 | 0.4108 | 0.04090 |
| | | | | | 6500 | 21.7 | 18.55 | 39.14 | 0.4216 | 0.04096 |
| | | | | | 7000 | 22.1 | 19.56 | 41.90 | 0.4324 | 0.04102 |
| | | | | P 265 70R 17 | 5250 | 21.6 | 15.03 | 39.62 | 0.3952 | 0.04111 |
| | | | | | 5500 | 21.9 | 15.54 | 41.38 | 0.4012 | 0.04115 |
| | | | | | 6000 | 22.5 | 16.51 | 44.91 | 0.4131 | 0.04124 |
| | | | | | 6500 | 23.1 | 17.43 | 48.44 | 0.4251 | 0.04132 |
| | | | | | 7000 | 23.6 | 18.31 | 51.98 | 0.4371 | 0.04141 |
| | | | | LT 245 75R 17 | 5250 | 22.2 | 14.65 | 45.82 | 0.3688 | 0.04080 |
| | | | | | 5500 | 22.5 | 15.14 | 47.76 | 0.3731 | 0.04083 |
| | | | | | 6000 | 23.1 | 16.09 | 51.64 | 0.3816 | 0.04088 |
| | | | | | 6500 | 23.6 | 17.00 | 55.51 | 0.3902 | 0.04094 |
| | | | | | 7000 | 24.2 | 17.86 | 59.36 | 0.3986 | 0.04099 |
| | | | | P 275 65R 18 | 5250 | 20.8 | 15.62 | 36.01 | 0.3621 | 0.04077 |
| | | | | | 5500 | 21.1 | 16.15 | 37.76 | 0.3672 | 0.04080 |
| | | | | | 6000 | 21.6 | 17.16 | 41.29 | 0.3775 | 0.04086 |
| | | | | | 6500 | 22.2 | 18.11 | 44.85 | 0.3879 | 0.04091 |
| | | | | | 7000 | 22.8 | 19.01 | 48.45 | 0.3985 | 0.04097 |
| | | | | LT 275 65R 18 | 5250 | 23.6 | 13.74 | 54.87 | 0.3681 | 0.04157 |
| | | | | | 5500 | 24.0 | 14.17 | 57.23 | 0.3727 | 0.04163 |
| | | | | | 6000 | 24.7 | 15.00 | 61.92 | 0.3819 | 0.04175 |
| | | | | | 6500 | 25.4 | 15.79 | 66.60 | 0.3910 | 0.04187 |
| | | | | | 7000 | 26.2 | 16.53 | 71.25 | 0.4002 | 0.04199 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5250 | 21.7 | 14.97 | 44.15 | 0.3334 | 0.04077 |
| | | | | | 5500 | 22.0 | 15.46 | 46.21 | 0.3366 | 0.04080 |
| | | | | | 6000 | 22.6 | 16.41 | 50.34 | 0.3431 | 0.04085 |
| | | | | | 6500 | 23.2 | 17.30 | 54.50 | 0.3496 | 0.04091 |
| | | | | | 7000 | 23.8 | 18.15 | 58.67 | 0.3561 | 0.04096 |
| | | | | P 275 55R 20 AT | 5250 | 23.5 | 13.82 | 55.65 | 0.3719 | 0.04078 |
| | | | | | 5500 | 23.9 | 14.24 | 58.24 | 0.3769 | 0.04080 |
| | | | | | 6000 | 24.7 | 15.04 | 63.44 | 0.3871 | 0.04086 |
| | | | | | 6500 | 25.4 | 15.79 | 68.65 | 0.3973 | 0.04091 |
| | | | | | 7000 | 26.2 | 16.50 | 73.87 | 0.4075 | 0.04096 |
| | | | | P 275 55R 20 BSW | 5250 | 22.0 | 14.75 | 44.63 | 0.3807 | 0.04059 |
| | | | | | 5500 | 22.4 | 15.22 | 46.83 | 0.3867 | 0.04061 |
| | | | | | 6000 | 23.0 | 16.11 | 51.26 | 0.3987 | 0.04064 |
| | | | | | 6500 | 23.7 | 16.94 | 55.73 | 0.4108 | 0.04068 |
| | | | | | 7000 | 24.4 | 17.72 | 60.24 | 0.4231 | 0.04072 |
| | | | | P 275 45R 22 | 5250 | 23.3 | 13.91 | 51.32 | 0.4513 | 0.04048 |
| | | | | | 5500 | 23.7 | 14.37 | 53.33 | 0.4589 | 0.04049 |
| | | | | | 6000 | 24.3 | 15.26 | 57.32 | 0.4740 | 0.04051 |
| | | | | | 6500 | 24.9 | 16.11 | 61.26 | 0.4889 | 0.04053 |
| | | | | | 7000 | 25.6 | 16.92 | 65.17 | 0.5036 | 0.04055 |
| | | | | P 255 65R 17 | 5250 | 21.7 | 14.99 | 39.27 | 0.4161 | 0.04100 |
| | | | | | 5500 | 22.0 | 15.50 | 40.99 | 0.4219 | 0.04104 |
| | | | | | 6000 | 22.5 | 16.48 | 44.42 | 0.4335 | 0.04112 |
| | | | | | 6500 | 23.1 | 17.42 | 47.86 | 0.4452 | 0.04121 |
| | | | | | 7000 | 23.6 | 18.31 | 51.30 | 0.4569 | 0.04129 |
| F150 All SC except 163" WE | 3.5L GTDI | Auto | 4x4 | P 235 75R 17 | 5500 | 20.6 | 16.55 | 33.62 | 0.4000 | 0.04028 |
| | | | | | 6000 | 21.0 | 17.66 | 36.38 | 0.4108 | 0.04034 |
| | | | | | 6500 | 21.5 | 18.71 | 39.14 | 0.4216 | 0.04040 |
| | | | | | 7000 | 22.0 | 19.73 | 41.90 | 0.4324 | 0.04046 |
| | | | | | 7500 | 22.4 | 20.70 | 44.67 | 0.4432 | 0.04052 |
| | | | | P 265 70R 17 | 5500 | 21.7 | 15.67 | 41.38 | 0.4012 | 0.04060 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 GTDi***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| **13P415_chart3.xls** | **7/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **Add new 20" tire** |
| **13P415_chart1.xls** | **3/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **New Track** |
| **13P415_chart.xls** | **10/12/2011** | **12P415_GTDi_4x2/4x4.RDMVer43.xls** | **43** | **Carryover 2012** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 6000 | 22.3 | 16.64 | 44.91 | 0.4131 | 0.04068 |
| | | | | | 6500 | 22.9 | 17.57 | 48.44 | 0.4251 | 0.04077 |
| | | | | | 7000 | 23.5 | 18.45 | 51.98 | 0.4371 | 0.04085 |
| | | | | | 7500 | 24.0 | 19.29 | 55.53 | 0.4491 | 0.04094 |
| | | | | LT 245 75R 17 | 5500 | 22.3 | 15.27 | 47.76 | 0.3731 | 0.04028 |
| | | | | | 6000 | 22.9 | 16.22 | 51.64 | 0.3816 | 0.04033 |
| | | | | | 6500 | 23.5 | 17.13 | 55.51 | 0.3902 | 0.04038 |
| | | | | | 7000 | 24.1 | 17.99 | 59.36 | 0.3986 | 0.04044 |
| | | | | | 7500 | 24.6 | 18.82 | 63.20 | 0.4071 | 0.04049 |
| | | | | P 275 65R 18 | 5500 | 20.9 | 16.29 | 37.76 | 0.3672 | 0.04025 |
| | | | | | 6000 | 21.5 | 17.31 | 41.29 | 0.3775 | 0.04030 |
| | | | | | 6500 | 22.0 | 18.26 | 44.85 | 0.3879 | 0.04036 |
| | | | | | 7000 | 22.6 | 19.17 | 48.45 | 0.3985 | 0.04042 |
| | | | | | 7500 | 23.2 | 20.03 | 52.07 | 0.4091 | 0.04047 |
| | | | | LT 275 65R 18 | 5500 | 23.8 | 14.28 | 57.23 | 0.3727 | 0.04108 |
| | | | | | 6000 | 24.5 | 15.12 | 61.92 | 0.3819 | 0.04120 |
| | | | | | 6500 | 25.3 | 15.90 | 66.60 | 0.3910 | 0.04132 |
| | | | | | 7000 | 26.0 | 16.65 | 71.25 | 0.4002 | 0.04144 |
| | | | | | 7500 | 26.7 | 17.36 | 75.89 | 0.4092 | 0.04156 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5500 | 21.8 | 15.59 | 46.21 | 0.3366 | 0.04024 |
| | | | | | 6000 | 22.4 | 16.54 | 50.34 | 0.3431 | 0.04030 |
| | | | | | 6500 | 23.0 | 17.44 | 54.50 | 0.3496 | 0.04035 |
| | | | | | 7000 | 23.7 | 18.29 | 58.67 | 0.3561 | 0.04040 |
| | | | | | 7500 | 24.3 | 19.09 | 62.85 | 0.3626 | 0.04046 |
| | | | | P 275 55R 20 AT | 5500 | 23.7 | 14.35 | 58.24 | 0.3769 | 0.04025 |
| | | | | | 6000 | 24.5 | 15.15 | 63.44 | 0.3871 | 0.04030 |
| | | | | | 6500 | 25.3 | 15.91 | 68.65 | 0.3973 | 0.04035 |
| | | | | | 7000 | 26.0 | 16.61 | 73.87 | 0.4075 | 0.04041 |
| | | | | | 7500 | 26.8 | 17.28 | 79.10 | 0.4178 | 0.04046 |
| | | | | P 275 55R 20 BSW | 5500 | 22.2 | 15.34 | 46.83 | 0.3867 | 0.04005 |
| | | | | | 6000 | 22.9 | 16.23 | 51.26 | 0.3987 | 0.04009 |
| | | | | | 6500 | 23.5 | 17.07 | 55.73 | 0.4108 | 0.04012 |
| | | | | | 7000 | 24.2 | 17.85 | 60.24 | 0.4231 | 0.04016 |
| | | | | | 7500 | 24.9 | 18.59 | 64.78 | 0.4354 | 0.04020 |
| | | | | P 275 45R 22 | 5500 | 23.5 | 14.48 | 53.33 | 0.4589 | 0.03994 |
| | | | | | 6000 | 24.1 | 15.38 | 57.32 | 0.4740 | 0.03996 |
| | | | | | 6500 | 24.8 | 16.23 | 61.26 | 0.4889 | 0.03998 |
| | | | | | 7000 | 25.4 | 17.05 | 65.17 | 0.5036 | 0.03999 |
| | | | | | 7500 | 26.0 | 17.83 | 69.04 | 0.5182 | 0.04001 |
| | | | | P 255 65R 17 | 5500 | 21.8 | 15.63 | 40.99 | 0.4219 | 0.04048 |
| | | | | | 6000 | 22.3 | 16.62 | 44.42 | 0.4335 | 0.04057 |
| | | | | | 6500 | 22.9 | 17.56 | 47.86 | 0.4452 | 0.04065 |
| | | | | | 7000 | 23.5 | 18.45 | 51.30 | 0.4569 | 0.04074 |
| | | | | | 7500 | 24.0 | 19.30 | 54.74 | 0.4685 | 0.04082 |
| F150 SC w/163" WB | 3.5L GTDI | Auto | 4x4 | P 235 75R 17 | 5500 | 20.9 | 16.31 | 33.62 | 0.4000 | 0.04118 |
| | | | | | 6000 | 21.3 | 17.41 | 36.38 | 0.4108 | 0.04124 |
| | | | | | 6500 | 21.8 | 18.46 | 39.14 | 0.4216 | 0.04130 |
| | | | | | 7000 | 22.3 | 19.46 | 41.90 | 0.4324 | 0.04136 |
| | | | | | 7500 | 22.7 | 20.43 | 44.67 | 0.4432 | 0.04142 |
| | | | | P 265 70R 17 | 5500 | 22.0 | 15.46 | 41.38 | 0.4012 | 0.04149 |
| | | | | | 6000 | 22.6 | 16.42 | 44.91 | 0.4131 | 0.04158 |
| | | | | | 6500 | 23.2 | 17.35 | 48.44 | 0.4251 | 0.04166 |
| | | | | | 7000 | 23.8 | 18.22 | 51.98 | 0.4371 | 0.04175 |
| | | | | | 7500 | 24.3 | 19.05 | 55.53 | 0.4491 | 0.04184 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 GTDi***

| Coverage Chart | Date | RDM file | Version | | Comments | | | |
|---|---|---|---|---|---|---|---|---|
| **13P415_chart3.xls** | **7/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | | **Add new 20" tire** | | | |
| **13P415_chart1.xls** | **3/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | | **New Track** | | | |
| **13P415_chart.xls** | **10/12/2011** | **12P415_GTDi_4x2/4x4.RDMVer43.xls** | **43** | | **Carryover 2012** | | | |
| | | LT 245 75R 17 | 5500 | 22.6 | 15.07 | 47.76 | 0.3731 | 0.04117 |
| | | | 6000 | 23.2 | 16.02 | 51.64 | 0.3816 | 0.04122 |
| | | | 6500 | 23.8 | 16.91 | 55.51 | 0.3902 | 0.04128 |
| | | | 7000 | 24.3 | 17.77 | 59.36 | 0.3986 | 0.04133 |
| | | | 7500 | 24.9 | 18.59 | 63.20 | 0.4071 | 0.04138 |
| | | P 275 65R 18 | 5500 | 21.2 | 16.06 | 37.76 | 0.3672 | 0.04114 |
| | | | 6000 | 21.8 | 17.07 | 41.29 | 0.3775 | 0.04120 |
| | | | 6500 | 22.3 | 18.02 | 44.85 | 0.3879 | 0.04125 |
| | | | 7000 | 22.9 | 18.92 | 48.45 | 0.3985 | 0.04131 |
| | | | 7500 | 23.5 | 19.77 | 52.07 | 0.4091 | 0.04137 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 GTDi***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| **13P415_chart3.xls** | **7/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **Add new 20" tire** |
| **13P415_chart1.xls** | **3/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **New Track** |
| **13P415_chart.xls** | **10/12/2011** | **12P415_GTDi_4x2/4x4.RDMVer43.xls** | **43** | **Carryover 2012** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | LT 275 65R 18 | 5500 | 24.1 | 14.11 | 57.23 | 0.3727 | 0.04197 |
| | | | | | 6000 | 24.8 | 14.94 | 61.92 | 0.3819 | 0.04209 |
| | | | | | 6500 | 25.6 | 15.72 | 66.60 | 0.3910 | 0.04221 |
| | | | | | 7000 | 26.3 | 16.46 | 71.25 | 0.4002 | 0.04233 |
| | | | | | 7500 | 27.0 | 17.17 | 75.89 | 0.4092 | 0.04245 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5500 | 22.1 | 15.38 | 46.21 | 0.3366 | 0.04114 |
| | | | | | 6000 | 22.7 | 16.33 | 50.34 | 0.3431 | 0.04119 |
| | | | | | 6500 | 23.3 | 17.22 | 54.50 | 0.3496 | 0.04124 |
| | | | | | 7000 | 24.0 | 18.06 | 58.67 | 0.3561 | 0.04130 |
| | | | | | 7500 | 24.6 | 18.86 | 62.85 | 0.3626 | 0.04135 |
| | | | | P 275 55R 20 AT | 5500 | 24.0 | 14.17 | 58.24 | 0.3769 | 0.04114 |
| | | | | | 6000 | 24.8 | 14.97 | 63.44 | 0.3871 | 0.04119 |
| | | | | | 6500 | 25.6 | 15.72 | 68.65 | 0.3973 | 0.04125 |
| | | | | | 7000 | 26.3 | 16.42 | 73.87 | 0.4075 | 0.04130 |
| | | | | | 7500 | 27.1 | 17.09 | 79.10 | 0.4178 | 0.04135 |
| | | | | P 275 55R 20 BSW | 5500 | 22.5 | 15.14 | 46.83 | 0.3867 | 0.04095 |
| | | | | | 6000 | 23.2 | 16.03 | 51.26 | 0.3987 | 0.04098 |
| | | | | | 6500 | 23.8 | 16.86 | 55.73 | 0.4108 | 0.04102 |
| | | | | | 7000 | 24.5 | 17.63 | 60.24 | 0.4231 | 0.04106 |
| | | | | | 7500 | 25.2 | 18.37 | 64.78 | 0.4354 | 0.04109 |
| | | | | P 275 45R 22 | 5500 | 23.8 | 14.30 | 53.33 | 0.4589 | 0.04083 |
| | | | | | 6000 | 24.4 | 15.19 | 57.32 | 0.4740 | 0.04085 |
| | | | | | 6500 | 25.1 | 16.04 | 61.26 | 0.4889 | 0.04087 |
| | | | | | 7000 | 25.7 | 16.85 | 65.17 | 0.5036 | 0.04089 |
| | | | | | 7500 | 26.3 | 17.63 | 69.04 | 0.5182 | 0.04091 |
| | | | | P 255 65R 17 | 5500 | 22.1 | 15.42 | 40.99 | 0.4219 | 0.04138 |
| | | | | | 6000 | 22.6 | 16.40 | 44.42 | 0.4335 | 0.04146 |
| | | | | | 6500 | 23.2 | 17.33 | 47.86 | 0.4452 | 0.04155 |
| | | | | | 7000 | 23.8 | 18.22 | 51.30 | 0.4569 | 0.04163 |
| | | | | | 7500 | 24.3 | 19.06 | 54.74 | 0.4685 | 0.04172 |
| F150 All CC | 3.5L GTDI | Auto | 4x4 | P 235 75R 17 | 5500 | 20.4 | 16.67 | 33.62 | 0.4000 | 0.03983 |
| | | | | | 6000 | 20.9 | 17.78 | 36.38 | 0.4108 | 0.03989 |
| | | | | | 6500 | 21.3 | 18.85 | 39.14 | 0.4216 | 0.03995 |
| | | | | | 7000 | 21.8 | 19.86 | 41.90 | 0.4324 | 0.04001 |
| | | | | P 265 70R 17 | 5500 | 21.6 | 15.77 | 41.38 | 0.4012 | 0.04015 |
| | | | | | 6000 | 22.2 | 16.76 | 44.91 | 0.4131 | 0.04023 |
| | | | | | 6500 | 22.7 | 17.69 | 48.44 | 0.4251 | 0.04032 |
| | | | | | 7000 | 23.3 | 18.57 | 51.98 | 0.4371 | 0.04041 |
| | | | | LT 245 75R 17 | 5500 | 22.1 | 15.37 | 47.76 | 0.3731 | 0.03983 |
| | | | | | 6000 | 22.7 | 16.33 | 51.64 | 0.3816 | 0.03988 |
| | | | | | 6500 | 23.3 | 17.24 | 55.51 | 0.3902 | 0.03994 |
| | | | | | 7000 | 23.9 | 18.10 | 59.36 | 0.3986 | 0.03999 |
| | | | | P 275 65R 18 | 5500 | 20.7 | 16.41 | 37.76 | 0.3672 | 0.03980 |
| | | | | | 6000 | 21.3 | 17.42 | 41.29 | 0.3775 | 0.03986 |
| | | | | | 6500 | 21.9 | 18.39 | 44.85 | 0.3879 | 0.03991 |
| | | | | | 7000 | 22.4 | 19.30 | 48.45 | 0.3985 | 0.03997 |
| | | | | LT 275 65R 18 | 5500 | 23.7 | 14.37 | 57.23 | 0.3727 | 0.04063 |
| | | | | | 6000 | 24.4 | 15.21 | 61.92 | 0.3819 | 0.04075 |
| | | | | | 6500 | 25.1 | 16.00 | 66.60 | 0.3910 | 0.04087 |
| | | | | | 7000 | 25.8 | 16.75 | 71.25 | 0.4002 | 0.04099 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5500 | 21.7 | 15.70 | 46.21 | 0.3366 | 0.03980 |
| | | | | | 6000 | 22.3 | 16.65 | 50.34 | 0.3431 | 0.03985 |
| | | | | | 6500 | 22.9 | 17.55 | 54.50 | 0.3496 | 0.03990 |
| | | | | | 7000 | 23.5 | 18.40 | 58.67 | 0.3561 | 0.03996 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 GTDi***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| **13P415_chart3.xls** | **7/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **Add new 20" tire** |
| **13P415_chart1.xls** | **3/12/2012** | **12/3P415_GTDi_4x2.1/4x4.1.RDMVer43.xls** | **43** | **New Track** |
| **13P415_chart.xls** | **10/12/2011** | **12P415_GTDi_4x2/4x4.RDMVer43.xls** | **43** | **Carryover 2012** |

| | | | | | | |
|---|---|---|---|---|---|---|
| P 275 55R 20 AT | 5500 | 23.5 | 14.44 | 58.24 | 0.3769 | 0.03980 |
| | 6000 | 24.3 | 15.25 | 63.44 | 0.3871 | 0.03985 |
| | 6500 | 25.1 | 16.00 | 68.65 | 0.3973 | 0.03991 |
| | 7000 | 25.9 | 16.71 | 73.87 | 0.4075 | 0.03996 |
| P 275 55R 20 BSW | 5500 | 22.0 | 15.45 | 46.83 | 0.3867 | 0.03960 |
| | 6000 | 22.7 | 16.34 | 51.26 | 0.3987 | 0.03964 |
| | 6500 | 23.4 | 17.18 | 55.73 | 0.4108 | 0.03968 |
| | 7000 | 24.1 | 17.96 | 60.24 | 0.4231 | 0.03971 |
| P 275 45R 22 | 5500 | 23.3 | 14.57 | 53.33 | 0.4589 | 0.03949 |
| | 6000 | 24.0 | 15.47 | 57.32 | 0.4740 | 0.03951 |
| | 6500 | 24.6 | 16.33 | 61.26 | 0.4889 | 0.03953 |
| | 7000 | 25.2 | 17.15 | 65.17 | 0.5036 | 0.03955 |
| P 255 65R 17 | 5500 | 21.6 | 15.74 | 40.99 | 0.4219 | 0.04004 |
| | 6000 | 22.2 | 16.73 | 44.42 | 0.4335 | 0.04012 |
| | 6500 | 22.8 | 17.67 | 47.86 | 0.4452 | 0.04021 |
| | 7000 | 23.3 | 18.57 | 51.30 | 0.4569 | 0.04029 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 3.7L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart2.xls | 4/9/2012 | 13P415_3.7SFE_4x2.1.RDMVer43.xls | 43 | SFE Package |
| 13P415_chart1.xls | 3/12/2012 | 12P415_3.7_4x2.1/4x4.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_3.7_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| F150 RCS SFE Package w/tonneau cover | 3.7L | Auto | 4x2 | P 235 75R 17 | 5000 | 17.3 | 17.86 | 17.79 | 0.8314 | 0.02826 |
| | | | | | 5250 | 17.6 | 18.51 | 19.17 | 0.8368 | 0.02829 |
| | | | | | 5500 | 17.8 | 19.14 | 20.54 | 0.8422 | 0.02832 |
| | | | | | 6000 | 18.3 | 20.35 | 23.30 | 0.8530 | 0.02838 |
| | | | | | 6500 | 18.7 | 21.49 | 26.06 | 0.8638 | 0.02844 |
| F150 RCS | 3.7L | Auto | 4x2 | P 235 75R 17 | 5000 | 17.9 | 17.25 | 17.79 | 0.8314 | 0.03010 |
| | | | | | 5250 | 18.2 | 17.88 | 19.17 | 0.8368 | 0.03013 |
| | | | | | 5500 | 18.4 | 18.50 | 20.54 | 0.8422 | 0.03016 |
| | | | | | 6000 | 18.9 | 19.69 | 23.30 | 0.8530 | 0.03022 |
| | | | | | 6500 | 19.3 | 20.82 | 26.06 | 0.8638 | 0.03028 |
| | | | | P 255 65R 17 | 5000 | 19.0 | 16.33 | 24.13 | 0.8790 | 0.02962 |
| | | | | | 5250 | 19.2 | 16.89 | 25.85 | 0.8848 | 0.02966 |
| | | | | | 5500 | 19.5 | 17.44 | 27.56 | 0.8906 | 0.02970 |
| | | | | | 6000 | 20.1 | 18.49 | 30.99 | 0.9023 | 0.02979 |
| | | | | | 6500 | 20.6 | 19.48 | 34.43 | 0.9139 | 0.02987 |
| | | | | LT 275 65R 18 | 5000 | 21.0 | 14.71 | 39.90 | 0.7709 | 0.03168 |
| | | | | | 5250 | 21.4 | 15.18 | 42.27 | 0.7755 | 0.03174 |
| | | | | | 5500 | 21.8 | 15.63 | 44.62 | 0.7802 | 0.03180 |
| | | | | | 6000 | 22.5 | 16.50 | 49.32 | 0.7893 | 0.03192 |
| | | | | | 6500 | 23.2 | 17.31 | 54.00 | 0.7985 | 0.03204 |
| | | | | LT 245 75R 17 | 5000 | 19.6 | 15.80 | 31.03 | 0.7891 | 0.03053 |
| | | | | | 5250 | 19.9 | 16.34 | 32.98 | 0.7934 | 0.03056 |
| | | | | | 5500 | 20.2 | 16.87 | 34.92 | 0.7977 | 0.03059 |
| | | | | | 6000 | 20.8 | 17.87 | 38.80 | 0.8062 | 0.03064 |
| | | | | | 6500 | 21.4 | 18.82 | 42.67 | 0.8147 | 0.03069 |
| | | | | P 265 60R 18 | 5000 | 18.4 | 16.81 | 21.01 | 0.8707 | 0.02944 |
| | | | | | 5250 | 18.7 | 17.39 | 22.66 | 0.8778 | 0.02945 |
| | | | | | 5500 | 19.0 | 17.95 | 24.32 | 0.8848 | 0.02946 |
| | | | | | 6000 | 19.5 | 19.03 | 27.66 | 0.8990 | 0.02949 |
| | | | | | 6500 | 20.1 | 20.04 | 31.02 | 0.9133 | 0.02951 |
| | | | | P 275 55R 20 AS | 5000 | 19.1 | 16.17 | 29.43 | 0.7422 | 0.03080 |
| | | | | | 5250 | 19.4 | 16.71 | 31.48 | 0.7454 | 0.03083 |
| | | | | | 5500 | 19.7 | 17.23 | 33.54 | 0.7487 | 0.03085 |
| | | | | | 6000 | 20.4 | 18.23 | 37.68 | 0.7551 | 0.03091 |
| | | | | | 6500 | 21.0 | 19.16 | 41.83 | 0.7616 | 0.03096 |
| | | | | P 265 70R 17 | 5000 | 19.0 | 16.25 | 25.07 | 0.8098 | 0.03091 |
| | | | | | 5250 | 19.3 | 16.80 | 26.83 | 0.8158 | 0.03096 |
| | | | | | 5500 | 19.6 | 17.34 | 28.59 | 0.8218 | 0.03100 |
| | | | | | 6000 | 20.2 | 18.37 | 32.12 | 0.8337 | 0.03109 |
| | | | | | 6500 | 20.8 | 19.35 | 35.66 | 0.8457 | 0.03117 |
| | | | | P 275 65R 18 | 5000 | 18.3 | 16.93 | 21.66 | 0.7644 | 0.03091 |
| | | | | | 5250 | 18.6 | 17.51 | 23.40 | 0.7695 | 0.03094 |
| | | | | | 5500 | 18.8 | 18.07 | 25.15 | 0.7746 | 0.03096 |
| | | | | | 6000 | 19.4 | 19.14 | 28.68 | 0.7850 | 0.03102 |
| | | | | | 6500 | 20.0 | 20.15 | 32.25 | 0.7954 | 0.03108 |
| F150 RCL | 3.7L | Auto | 4x2 | P 235 75R 17 | 5000 | 18.2 | 17.03 | 17.79 | 0.8314 | 0.03080 |
| | | | | | 5250 | 18.4 | 17.66 | 19.17 | 0.8368 | 0.03083 |
| | | | | | 5500 | 18.6 | 18.27 | 20.54 | 0.8422 | 0.03086 |
| | | | | | 6000 | 19.1 | 19.45 | 23.30 | 0.8530 | 0.03092 |

| ROADLOAD CERTIFICATION SPECIFICATIONS | | | 2013 F150 3.7L | |
|---|---|---|---|---|
| **Coverage Chart** | **Date** | **RDM file** | **Version** | **Comments** |
| 13P415_chart2.xls | 4/9/2012 | 13P415_3.7SFE_4x2.1.RDMVer43.xls | 43 | SFE Package |
| 13P415_chart1.xls | 3/12/2012 | 12P415_3.7_4x2.1/4x4.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_3.7_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|
| | 6500 | 19.6 | 20.57 | 26.06 | 0.8638 | 0.03098 |
| P 255 65R 17 | 5000 | 19.2 | 16.13 | 24.13 | 0.8790 | 0.03032 |
| | 5250 | 19.5 | 16.69 | 25.85 | 0.8848 | 0.03036 |
| | 5500 | 19.7 | 17.24 | 27.56 | 0.8906 | 0.03040 |
| | 6000 | 20.3 | 18.28 | 30.99 | 0.9023 | 0.03049 |
| | 6500 | 20.9 | 19.26 | 34.43 | 0.9139 | 0.03057 |
| LT 275 65R 18 | 5000 | 21.3 | 14.55 | 39.90 | 0.7709 | 0.03238 |
| | 5250 | 21.6 | 15.02 | 42.27 | 0.7755 | 0.03244 |
| | 5500 | 22.0 | 15.47 | 44.62 | 0.7802 | 0.03250 |
| | 6000 | 22.7 | 16.33 | 49.32 | 0.7893 | 0.03262 |
| | 6500 | 23.4 | 17.14 | 54.00 | 0.7985 | 0.03274 |
| LT 245 75R 17 | 5000 | 19.8 | 15.62 | 31.03 | 0.7891 | 0.03123 |
| | 5250 | 20.1 | 16.15 | 32.98 | 0.7934 | 0.03126 |
| | 5500 | 20.4 | 16.67 | 34.92 | 0.7977 | 0.03129 |
| | 6000 | 21.0 | 17.67 | 38.80 | 0.8062 | 0.03134 |
| | 6500 | 21.6 | 18.62 | 42.67 | 0.8147 | 0.03139 |
| P 265 60R 18 | 5000 | 18.7 | 16.60 | 21.01 | 0.8707 | 0.03014 |
| | 5250 | 18.9 | 17.17 | 22.66 | 0.8778 | 0.03015 |
| | 5500 | 19.2 | 17.73 | 24.32 | 0.8848 | 0.03017 |
| | 6000 | 19.7 | 18.80 | 27.66 | 0.8990 | 0.03019 |
| | 6500 | 20.3 | 19.82 | 31.02 | 0.9133 | 0.03021 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

**2013 F150 3.7L**

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart2.xls | 4/9/2012 | 13P415_3.7SFE_4x2.1.RDMVer43.xls | 43 | SFE Package |
| 13P415_chart1.xls | 3/12/2012 | 12P415_3.7_4x2.1/4x4.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_3.7_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | P 275 55R 20 AS | 5000 | 19.4 | 15.97 | 29.43 | 0.7422 | 0.03150 |
| | | | | | 5250 | 19.7 | 16.51 | 31.48 | 0.7454 | 0.03153 |
| | | | | | 5500 | 20.0 | 17.03 | 33.54 | 0.7487 | 0.03155 |
| | | | | | 6000 | 20.6 | 18.02 | 37.68 | 0.7551 | 0.03161 |
| | | | | | 6500 | 21.2 | 18.95 | 41.83 | 0.7616 | 0.03166 |
| | | | | P 265 70R 17 | 5000 | 19.3 | 16.05 | 25.07 | 0.8098 | 0.03161 |
| | | | | | 5250 | 19.6 | 16.60 | 26.83 | 0.8158 | 0.03166 |
| | | | | | 5500 | 19.9 | 17.14 | 28.59 | 0.8218 | 0.03170 |
| | | | | | 6000 | 20.4 | 18.16 | 32.12 | 0.8337 | 0.03179 |
| | | | | | 6500 | 21.0 | 19.13 | 35.66 | 0.8457 | 0.03187 |
| | | | | P 275 65R 18 | 5000 | 18.5 | 16.72 | 21.66 | 0.7644 | 0.03161 |
| | | | | | 5250 | 18.8 | 17.29 | 23.40 | 0.7695 | 0.03164 |
| | | | | | 5500 | 19.1 | 17.85 | 25.15 | 0.7746 | 0.03167 |
| | | | | | 6000 | 19.6 | 18.92 | 28.68 | 0.7850 | 0.03172 |
| | | | | | 6500 | 20.2 | 19.91 | 32.25 | 0.7954 | 0.03178 |
| F150 All SC except 163" WE | 3.7L | Auto | 4x2 | P 235 75R 17 | 5250 | 18.1 | 18.00 | 19.17 | 0.8368 | 0.02978 |
| | | | | | 5500 | 18.3 | 18.62 | 20.54 | 0.8422 | 0.02981 |
| | | | | | 6000 | 18.8 | 19.81 | 23.30 | 0.8530 | 0.02987 |
| | | | | | 6500 | 19.2 | 20.94 | 26.06 | 0.8638 | 0.02993 |
| | | | | | 7000 | 19.7 | 22.02 | 28.82 | 0.8746 | 0.02999 |
| | | | | P 255 65R 17 | 5250 | 19.1 | 17.00 | 25.85 | 0.8848 | 0.02931 |
| | | | | | 5500 | 19.4 | 17.55 | 27.56 | 0.8906 | 0.02935 |
| | | | | | 6000 | 20.0 | 18.60 | 30.99 | 0.9023 | 0.02944 |
| | | | | | 6500 | 20.5 | 19.59 | 34.43 | 0.9139 | 0.02952 |
| | | | | | 7000 | 21.1 | 20.53 | 37.87 | 0.9256 | 0.02961 |
| | | | | LT 275 65R 18 | 5250 | 21.3 | 15.26 | 42.27 | 0.7755 | 0.03139 |
| | | | | | 5500 | 21.6 | 15.72 | 44.62 | 0.7802 | 0.03145 |
| | | | | | 6000 | 22.4 | 16.59 | 49.32 | 0.7893 | 0.03157 |
| | | | | | 6500 | 23.1 | 17.40 | 54.00 | 0.7985 | 0.03169 |
| | | | | | 7000 | 23.8 | 18.17 | 58.65 | 0.8076 | 0.03181 |
| | | | | LT 245 75R 17 | 5250 | 19.8 | 16.44 | 32.98 | 0.7934 | 0.03021 |
| | | | | | 5500 | 20.1 | 16.96 | 34.92 | 0.7977 | 0.03024 |
| | | | | | 6000 | 20.6 | 17.97 | 38.80 | 0.8062 | 0.03029 |
| | | | | | 6500 | 21.2 | 18.93 | 42.67 | 0.8147 | 0.03034 |
| | | | | | 7000 | 21.8 | 19.83 | 46.52 | 0.8232 | 0.03039 |
| | | | | P 265 60R 18 | 5250 | 18.6 | 17.50 | 22.66 | 0.8778 | 0.02910 |
| | | | | | 5500 | 18.8 | 18.06 | 24.32 | 0.8848 | 0.02911 |
| | | | | | 6000 | 19.4 | 19.14 | 27.66 | 0.8990 | 0.02914 |
| | | | | | 6500 | 19.9 | 20.16 | 31.02 | 0.9133 | 0.02916 |
| | | | | | 7000 | 20.5 | 21.12 | 34.40 | 0.9277 | 0.02919 |
| | | | | P 275 55R 20 AS | 5250 | 19.3 | 16.81 | 31.48 | 0.7454 | 0.03048 |
| | | | | | 5500 | 19.6 | 17.33 | 33.54 | 0.7487 | 0.03050 |
| | | | | | 6000 | 20.2 | 18.33 | 37.68 | 0.7551 | 0.03056 |
| | | | | | 6500 | 20.9 | 19.27 | 41.83 | 0.7616 | 0.03061 |
| | | | | | 7000 | 21.5 | 20.15 | 46.00 | 0.7681 | 0.03066 |
| | | | | P 265 70R 17 | 5250 | 19.2 | 16.91 | 26.83 | 0.8158 | 0.03061 |
| | | | | | 5500 | 19.5 | 17.45 | 28.59 | 0.8218 | 0.03065 |
| | | | | | 6000 | 20.1 | 18.48 | 32.12 | 0.8337 | 0.03074 |
| | | | | | 6500 | 20.7 | 19.45 | 35.66 | 0.8457 | 0.03082 |
| | | | | | 7000 | 21.2 | 20.37 | 39.20 | 0.8577 | 0.03091 |
| | | | | P 275 65R 18 | 5250 | 18.4 | 17.62 | 23.40 | 0.7695 | 0.03059 |
| | | | | | 5500 | 18.7 | 18.19 | 25.15 | 0.7746 | 0.03061 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

**2013 F150 3.7L**

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart2.xls | 4/9/2012 | 13P415_3.7SFE_4x2.1.RDMVer43.xls | 43 | SFE Package |
| 13P415_chart1.xls | 3/12/2012 | 12P415_3.7_4x2.1/4x4.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_3.7_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 6000 | 19.3 | 19.26 | 28.68 | 0.7850 | 0.03067 |
| | | | | | 6500 | 19.8 | 20.26 | 32.25 | 0.7954 | 0.03073 |
| | | | | | 7000 | 20.4 | 21.21 | 35.84 | 0.8059 | 0.03078 |
| F150 SC w/163" WB | 3.7L | Auto | 4x2 | P 235 75R 17 | 5250 | 18.3 | 17.74 | 19.17 | 0.8368 | 0.03057 |
| | | | | | 5500 | 18.6 | 18.36 | 20.54 | 0.8422 | 0.03060 |
| | | | | | 6000 | 19.0 | 19.54 | 23.30 | 0.8530 | 0.03066 |
| | | | | | 6500 | 19.5 | 20.66 | 26.06 | 0.8638 | 0.03072 |
| | | | | | 7000 | 19.9 | 21.73 | 28.82 | 0.8746 | 0.03078 |
| | | | | P 255 65R 17 | 5250 | 19.4 | 16.77 | 25.85 | 0.8848 | 0.03010 |
| | | | | | 5500 | 19.7 | 17.31 | 27.56 | 0.8906 | 0.03014 |
| | | | | | 6000 | 20.2 | 18.35 | 30.99 | 0.9023 | 0.03023 |
| | | | | | 6500 | 20.8 | 19.34 | 34.43 | 0.9139 | 0.03031 |
| | | | | | 7000 | 21.4 | 20.28 | 37.87 | 0.9256 | 0.03039 |
| | | | | LT 275 65R 18 | 5250 | 21.5 | 15.08 | 42.27 | 0.7755 | 0.03217 |
| | | | | | 5500 | 21.9 | 15.53 | 44.62 | 0.7802 | 0.03224 |
| | | | | | 6000 | 22.6 | 16.39 | 49.32 | 0.7893 | 0.03236 |
| | | | | | 6500 | 23.4 | 17.20 | 54.00 | 0.7985 | 0.03248 |
| | | | | | 7000 | 24.1 | 17.97 | 58.65 | 0.8076 | 0.03260 |
| | | | | LT 245 75R 17 | 5250 | 20.0 | 16.22 | 32.98 | 0.7934 | 0.03100 |
| | | | | | 5500 | 20.3 | 16.75 | 34.92 | 0.7977 | 0.03102 |
| | | | | | 6000 | 20.9 | 17.75 | 38.80 | 0.8062 | 0.03108 |
| | | | | | 6500 | 21.5 | 18.70 | 42.67 | 0.8147 | 0.03113 |
| | | | | | 7000 | 22.1 | 19.60 | 46.52 | 0.8232 | 0.03118 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

**2013 F150 3.7L**

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart2.xls | 4/9/2012 | 13P415_3.7SFE_4x2.1.RDMVer43.xls | 43 | SFE Package |
| 13P415_chart1.xls | 3/12/2012 | 12P415_3.7_4x2.1/4x4.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_3.7_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | P 265 60R 18 | 5250 | 18.8 | 17.25 | 22.66 | 0.8778 | 0.02989 |
| | | | | | 5500 | 19.1 | 17.82 | 24.32 | 0.8848 | 0.02990 |
| | | | | | 6000 | 19.7 | 18.89 | 27.66 | 0.8990 | 0.02993 |
| | | | | | 6500 | 20.2 | 19.90 | 31.02 | 0.9133 | 0.02995 |
| | | | | | 7000 | 20.8 | 20.86 | 34.40 | 0.9277 | 0.02997 |
| | | | | P 275 55R 20 AS | 5250 | 19.6 | 16.58 | 31.48 | 0.7454 | 0.03127 |
| | | | | | 5500 | 19.9 | 17.10 | 33.54 | 0.7487 | 0.03129 |
| | | | | | 6000 | 20.5 | 18.10 | 37.68 | 0.7551 | 0.03135 |
| | | | | | 6500 | 21.1 | 19.03 | 41.83 | 0.7616 | 0.03140 |
| | | | | | 7000 | 21.7 | 19.91 | 46.00 | 0.7681 | 0.03145 |
| | | | | P 265 70R 17 | 5250 | 19.5 | 16.68 | 26.83 | 0.8158 | 0.03140 |
| | | | | | 5500 | 19.8 | 17.22 | 28.59 | 0.8218 | 0.03144 |
| | | | | | 6000 | 20.3 | 18.24 | 32.12 | 0.8337 | 0.03152 |
| | | | | | 6500 | 20.9 | 19.21 | 35.66 | 0.8457 | 0.03161 |
| | | | | | 7000 | 21.5 | 20.13 | 39.20 | 0.8577 | 0.03170 |
| | | | | P 275 65R 18 | 5250 | 18.7 | 17.37 | 23.40 | 0.7695 | 0.03137 |
| | | | | | 5500 | 19.0 | 17.93 | 25.15 | 0.7746 | 0.03140 |
| | | | | | 6000 | 19.5 | 19.00 | 28.68 | 0.7850 | 0.03146 |
| | | | | | 6500 | 20.1 | 20.00 | 32.25 | 0.7954 | 0.03152 |
| | | | | | 7000 | 20.7 | 20.94 | 35.84 | 0.8059 | 0.03157 |
| F150 All CC | 3.7L | Auto | 4x2 | P 235 75R 17 | 5500 | 18.1 | 18.82 | 20.54 | 0.8422 | 0.02923 |
| | | | | | 6000 | 18.6 | 20.01 | 23.30 | 0.8530 | 0.02929 |
| | | | | | 6500 | 19.0 | 21.15 | 26.06 | 0.8638 | 0.02935 |
| | | | | P 255 65R 17 | 5500 | 19.2 | 17.72 | 27.56 | 0.8906 | 0.02877 |
| | | | | | 6000 | 19.8 | 18.78 | 30.99 | 0.9023 | 0.02885 |
| | | | | | 6500 | 20.3 | 19.78 | 34.43 | 0.9139 | 0.02894 |
| | | | | LT 275 65R 18 | 5500 | 21.4 | 15.86 | 44.62 | 0.7802 | 0.03086 |
| | | | | | 6000 | 22.2 | 16.73 | 49.32 | 0.7893 | 0.03098 |
| | | | | | 6500 | 22.9 | 17.55 | 54.00 | 0.7985 | 0.03110 |
| | | | | LT 245 75R 17 | 5500 | 19.9 | 17.13 | 34.92 | 0.7977 | 0.02965 |
| | | | | | 6000 | 20.4 | 18.14 | 38.80 | 0.8062 | 0.02970 |
| | | | | | 6500 | 21.0 | 19.10 | 42.67 | 0.8147 | 0.02976 |
| | | | | P 265 60R 18 | 5500 | 18.7 | 18.25 | 24.32 | 0.8848 | 0.02853 |
| | | | | | 6000 | 19.2 | 19.34 | 27.66 | 0.8990 | 0.02855 |
| | | | | | 6500 | 19.8 | 20.36 | 31.02 | 0.9133 | 0.02858 |
| | | | | P 275 55R 20 AS | 5500 | 19.4 | 17.50 | 33.54 | 0.7487 | 0.02992 |
| | | | | | 6000 | 20.0 | 18.51 | 37.68 | 0.7551 | 0.02997 |
| | | | | | 6500 | 20.7 | 19.45 | 41.83 | 0.7616 | 0.03003 |
| | | | | P 265 70R 17 | 5500 | 19.3 | 17.62 | 28.59 | 0.8218 | 0.03007 |
| | | | | | 6000 | 19.9 | 18.66 | 32.12 | 0.8337 | 0.03015 |
| | | | | | 6500 | 20.5 | 19.64 | 35.66 | 0.8457 | 0.03024 |
| | | | | P 275 65R 18 | 5500 | 18.5 | 18.37 | 25.15 | 0.7746 | 0.03003 |
| | | | | | 6000 | 19.1 | 19.45 | 28.68 | 0.7850 | 0.03009 |
| | | | | | 6500 | 19.6 | 20.47 | 32.25 | 0.7954 | 0.03014 |
| F150 RCS | 3.7L | Auto | 4x4 | P 235 75R 17 | 5250 | 19.4 | 16.73 | 27.83 | 0.6323 | 0.03449 |
| | | | | | 5500 | 19.7 | 17.32 | 29.21 | 0.6377 | 0.03452 |
| | | | | | 6000 | 20.1 | 18.46 | 31.96 | 0.6485 | 0.03458 |
| | | | | | 6500 | 20.6 | 19.55 | 34.72 | 0.6593 | 0.03464 |
| | | | | | 7000 | 21.0 | 20.59 | 37.49 | 0.6701 | 0.03470 |
| | | | | P 265 70R 17 | 5250 | 20.5 | 15.81 | 35.30 | 0.6220 | 0.03508 |
| | | | | | 5500 | 20.8 | 16.33 | 37.06 | 0.6280 | 0.03513 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

**2013 F150 3.7L**

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart2.xls | 4/9/2012 | 13P415_3.7SFE_4x2.1.RDMVer43.xls | 43 | SFE Package |
| 13P415_chart1.xls | 3/12/2012 | 12P415_3.7_4x2.1/4x4.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_3.7_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|
| | 6000 | 21.4 | 17.33 | 40.60 | 0.6400 | 0.03521 |
| | 6500 | 22.0 | 18.27 | 44.13 | 0.6520 | 0.03530 |
| | 7000 | 22.6 | 19.17 | 47.67 | 0.6640 | 0.03539 |
| LT 245 75R 17 | 5250 | 21.1 | 15.40 | 41.48 | 0.5977 | 0.03473 |
| | 5500 | 21.4 | 15.90 | 43.43 | 0.6019 | 0.03475 |
| | 6000 | 22.0 | 16.88 | 47.31 | 0.6105 | 0.03481 |
| | 6500 | 22.6 | 17.80 | 51.18 | 0.6190 | 0.03486 |
| | 7000 | 23.2 | 18.68 | 55.03 | 0.6275 | 0.03491 |
| P 275 65R 18 | 5250 | 19.8 | 16.44 | 31.76 | 0.5824 | 0.03493 |
| | 5500 | 20.0 | 16.99 | 33.51 | 0.5875 | 0.03495 |
| | 6000 | 20.6 | 18.03 | 37.04 | 0.5978 | 0.03501 |
| | 6500 | 21.2 | 19.00 | 40.60 | 0.6082 | 0.03507 |
| | 7000 | 21.7 | 19.93 | 44.20 | 0.6188 | 0.03512 |
| LT 275 65R 18 | 5250 | 22.6 | 14.37 | 50.62 | 0.5884 | 0.03573 |
| | 5500 | 22.9 | 14.82 | 52.97 | 0.5930 | 0.03579 |
| | 6000 | 23.7 | 15.66 | 57.67 | 0.6022 | 0.03591 |
| | 6500 | 24.4 | 16.46 | 62.35 | 0.6113 | 0.03603 |
| | 7000 | 25.1 | 17.22 | 67.00 | 0.6205 | 0.03615 |
| P 275 55R 20 AS | 5250 | 20.6 | 15.73 | 39.88 | 0.5560 | 0.03487 |
| | 5500 | 21.0 | 16.24 | 41.94 | 0.5592 | 0.03489 |
| | 6000 | 21.6 | 17.21 | 46.07 | 0.5657 | 0.03494 |
| | 6500 | 22.2 | 18.12 | 50.22 | 0.5721 | 0.03500 |
| | 7000 | 22.8 | 18.98 | 54.39 | 0.5787 | 0.03505 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 3.7L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart2.xls | 4/9/2012 | 13P415_3.7SFE_4x2.1.RDMVer43.xls | 43 | SFE Package |
| 13P415_chart1.xls | 3/12/2012 | 12P415_3.7_4x2.1/4x4.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_3.7_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | P 275 55R 20 AT | 5250 | 22.4 | 14.46 | 51.38 | 0.5944 | 0.03487 |
| | | | | | 5500 | 22.8 | 14.89 | 53.97 | 0.5995 | 0.03490 |
| | | | | | 6000 | 23.6 | 15.71 | 59.17 | 0.6097 | 0.03495 |
| | | | | | 6500 | 24.4 | 16.47 | 64.38 | 0.6199 | 0.03500 |
| | | | | | 7000 | 25.2 | 17.18 | 69.60 | 0.6301 | 0.03505 |
| | | | | P 255 65R 17 | 5250 | 20.5 | 15.83 | 34.74 | 0.6670 | 0.03431 |
| | | | | | 5500 | 20.8 | 16.36 | 36.45 | 0.6728 | 0.03435 |
| | | | | | 6000 | 21.4 | 17.37 | 39.88 | 0.6845 | 0.03444 |
| | | | | | 6500 | 21.9 | 18.34 | 43.32 | 0.6961 | 0.03452 |
| | | | | | 7000 | 22.5 | 19.25 | 46.76 | 0.7078 | 0.03460 |
| F150 RCL | 3.7L | Auto | 4x4 | P 235 75R 17 | 5250 | 19.6 | 16.56 | 27.83 | 0.6323 | 0.03511 |
| | | | | | 5500 | 19.9 | 17.14 | 29.21 | 0.6377 | 0.03514 |
| | | | | | 6000 | 20.3 | 18.28 | 31.96 | 0.6485 | 0.03520 |
| | | | | | 6500 | 20.8 | 19.36 | 34.72 | 0.6593 | 0.03526 |
| | | | | | 7000 | 21.2 | 20.39 | 37.49 | 0.6701 | 0.03532 |
| | | | | P 265 70R 17 | 5250 | 20.8 | 15.65 | 35.30 | 0.6220 | 0.03570 |
| | | | | | 5500 | 21.0 | 16.17 | 37.06 | 0.6280 | 0.03575 |
| | | | | | 6000 | 21.6 | 17.16 | 40.60 | 0.6400 | 0.03583 |
| | | | | | 6500 | 22.2 | 18.11 | 44.13 | 0.6520 | 0.03592 |
| | | | | | 7000 | 22.8 | 19.00 | 47.67 | 0.6640 | 0.03601 |
| | | | | LT 245 75R 17 | 5250 | 21.3 | 15.25 | 41.48 | 0.5977 | 0.03535 |
| | | | | | 5500 | 21.6 | 15.75 | 43.43 | 0.6019 | 0.03538 |
| | | | | | 6000 | 22.2 | 16.72 | 47.31 | 0.6105 | 0.03543 |
| | | | | | 6500 | 22.8 | 17.64 | 51.18 | 0.6190 | 0.03548 |
| | | | | | 7000 | 23.4 | 18.52 | 55.03 | 0.6275 | 0.03553 |
| | | | | P 275 65R 18 | 5250 | 20.0 | 16.27 | 31.76 | 0.5824 | 0.03555 |
| | | | | | 5500 | 20.2 | 16.82 | 33.51 | 0.5875 | 0.03557 |
| | | | | | 6000 | 20.8 | 17.85 | 37.04 | 0.5978 | 0.03563 |
| | | | | | 6500 | 21.4 | 18.82 | 40.60 | 0.6082 | 0.03569 |
| | | | | | 7000 | 21.9 | 19.74 | 44.20 | 0.6188 | 0.03574 |
| | | | | LT 275 65R 18 | 5250 | 22.8 | 14.24 | 50.62 | 0.5884 | 0.03635 |
| | | | | | 5500 | 23.2 | 14.69 | 52.97 | 0.5930 | 0.03641 |
| | | | | | 6000 | 23.9 | 15.53 | 57.67 | 0.6022 | 0.03653 |
| | | | | | 6500 | 24.6 | 16.33 | 62.35 | 0.6113 | 0.03665 |
| | | | | | 7000 | 25.3 | 17.08 | 67.00 | 0.6205 | 0.03677 |
| | | | | P 275 55R 20 AS | 5250 | 20.9 | 15.57 | 39.88 | 0.5560 | 0.03549 |
| | | | | | 5500 | 21.2 | 16.08 | 41.94 | 0.5592 | 0.03551 |
| | | | | | 6000 | 21.8 | 17.04 | 46.07 | 0.5657 | 0.03557 |
| | | | | | 6500 | 22.4 | 17.95 | 50.22 | 0.5721 | 0.03562 |
| | | | | | 7000 | 23.0 | 18.81 | 54.39 | 0.5787 | 0.03567 |
| | | | | P 275 55R 20 AT | 5250 | 22.6 | 14.33 | 51.38 | 0.5944 | 0.03549 |
| | | | | | 5500 | 23.0 | 14.76 | 53.97 | 0.5995 | 0.03552 |
| | | | | | 6000 | 23.8 | 15.57 | 59.17 | 0.6097 | 0.03557 |
| | | | | | 6500 | 24.6 | 16.33 | 64.38 | 0.6199 | 0.03562 |
| | | | | | 7000 | 25.4 | 17.05 | 69.60 | 0.6301 | 0.03567 |
| | | | | P 255 65R 17 | 5250 | 20.7 | 15.68 | 34.74 | 0.6670 | 0.03493 |
| | | | | | 5500 | 21.0 | 16.20 | 36.45 | 0.6728 | 0.03497 |
| | | | | | 6000 | 21.6 | 17.21 | 39.88 | 0.6845 | 0.03506 |
| | | | | | 6500 | 22.1 | 18.17 | 43.32 | 0.6961 | 0.03514 |
| | | | | | 7000 | 22.7 | 19.07 | 46.76 | 0.7078 | 0.03522 |
| F150 All SC except 163" WE | 3.7L | Auto | 4x4 | P 235 75R 17 | 5500 | 19.6 | 17.36 | 29.21 | 0.6377 | 0.03439 |
| | | | | | 6000 | 20.1 | 18.50 | 31.96 | 0.6485 | 0.03445 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 3.7L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart2.xls | 4/9/2012 | 13P415_3.7SFE_4x2.1.RDMVer43.xls | 43 | SFE Package |
| 13P415_chart1.xls | 3/12/2012 | 12P415_3.7_4x2.1/4x4.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_3.7_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|
| | 6500 | 20.5 | 19.59 | 34.72 | 0.6593 | 0.03451 |
| | 7000 | 21.0 | 20.63 | 37.49 | 0.6701 | 0.03457 |
| | 7500 | 21.4 | 21.63 | 40.25 | 0.6809 | 0.03463 |
| P 265 70R 17 | 5500 | 20.8 | 16.36 | 37.06 | 0.6280 | 0.03500 |
| | 6000 | 21.4 | 17.36 | 40.60 | 0.6400 | 0.03509 |
| | 6500 | 22.0 | 18.31 | 44.13 | 0.6520 | 0.03518 |
| | 7000 | 22.5 | 19.21 | 47.67 | 0.6640 | 0.03526 |
| | 7500 | 23.1 | 20.06 | 51.22 | 0.6760 | 0.03535 |
| LT 245 75R 17 | 5500 | 21.3 | 15.93 | 43.43 | 0.6019 | 0.03463 |
| | 6000 | 21.9 | 16.91 | 47.31 | 0.6105 | 0.03468 |
| | 6500 | 22.5 | 17.84 | 51.18 | 0.6190 | 0.03474 |
| | 7000 | 23.1 | 18.72 | 55.03 | 0.6275 | 0.03479 |
| | 7500 | 23.7 | 19.56 | 58.87 | 0.6360 | 0.03484 |
| P 275 65R 18 | 5500 | 20.0 | 17.02 | 33.51 | 0.5875 | 0.03483 |
| | 6000 | 20.6 | 18.06 | 37.04 | 0.5978 | 0.03489 |
| | 6500 | 21.1 | 19.04 | 40.60 | 0.6082 | 0.03494 |
| | 7000 | 21.7 | 19.96 | 44.20 | 0.6188 | 0.03500 |
| | 7500 | 22.3 | 20.84 | 47.82 | 0.6294 | 0.03506 |
| LT 275 65R 18 | 5500 | 22.9 | 14.84 | 52.97 | 0.5930 | 0.03566 |
| | 6000 | 23.6 | 15.69 | 57.67 | 0.6022 | 0.03578 |
| | 6500 | 24.4 | 16.49 | 62.35 | 0.6113 | 0.03590 |
| | 7000 | 25.1 | 17.25 | 67.00 | 0.6205 | 0.03602 |
| | 7500 | 25.8 | 17.96 | 71.64 | 0.6295 | 0.03614 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

**2013 F150 3.7L**

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart2.xls | 4/9/2012 | 13P415_3.7SFE_4x2.1.RDMVer43.xls | 43 | SFE Package |
| 13P415_chart1.xls | 3/12/2012 | 12P415_3.7_4x2.1/4x4.RDMVer43.xls | 43 | New Track |
| 13P415_chart.xls | 10/12/2011 | 12P415_3.7_4x2/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|
| P 275 55R 20 AS | 5500 | 20.9 | 16.27 | 41.94 | 0.5592 | 0.03477 |
| | 6000 | 21.5 | 17.24 | 46.07 | 0.5657 | 0.03482 |
| | 6500 | 22.1 | 18.16 | 50.22 | 0.5721 | 0.03487 |
| | 7000 | 22.8 | 19.02 | 54.39 | 0.5787 | 0.03493 |
| | 7500 | 23.4 | 19.83 | 58.58 | 0.5852 | 0.03498 |
| P 275 55R 20 AT | 5500 | 22.8 | 14.92 | 53.97 | 0.5995 | 0.03477 |
| | 6000 | 23.6 | 15.74 | 59.17 | 0.6097 | 0.03482 |
| | 6500 | 24.3 | 16.50 | 64.38 | 0.6199 | 0.03488 |
| | 7000 | 25.1 | 17.21 | 69.60 | 0.6301 | 0.03493 |
| | 7500 | 25.9 | 17.88 | 74.83 | 0.6403 | 0.03498 |
| P 255 65R 17 | 5500 | 20.8 | 16.39 | 36.45 | 0.6728 | 0.03423 |
| | 6000 | 21.3 | 17.41 | 39.88 | 0.6845 | 0.03431 |
| | 6500 | 21.9 | 18.37 | 43.32 | 0.6961 | 0.03439 |
| | 7000 | 22.4 | 19.28 | 46.76 | 0.7078 | 0.03448 |
| | 7500 | 23.0 | 20.15 | 50.21 | 0.7195 | 0.03456 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 5.0L/6.2L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| F150 RCS | 5.0L | Auto | 4x2 | P 235 75R 17 | 5000 | 18.3 | 16.93 | 30.03 | 0.2722 | 0.03740 |
| | | | | | 5250 | 18.5 | 17.56 | 31.41 | 0.2776 | 0.03743 |
| | | | | | 5500 | 18.7 | 18.17 | 32.79 | 0.2830 | 0.03746 |
| | | | | | 6000 | 19.2 | 19.34 | 35.54 | 0.2938 | 0.03752 |
| | | | | | 6500 | 19.7 | 20.46 | 38.30 | 0.3046 | 0.03758 |
| | | | | P 255 65R 17 | 5000 | 19.3 | 16.01 | 36.71 | 0.2885 | 0.03754 |
| | | | | | 5250 | 19.6 | 16.56 | 38.43 | 0.2944 | 0.03758 |
| | | | | | 5500 | 19.9 | 17.11 | 40.14 | 0.3002 | 0.03762 |
| | | | | | 6000 | 20.5 | 18.14 | 43.57 | 0.3118 | 0.03771 |
| | | | | | 6500 | 21.0 | 19.13 | 47.01 | 0.3235 | 0.03779 |
| | | | | LT 275 65R 18 | 5000 | 21.3 | 14.51 | 51.69 | 0.2526 | 0.03819 |
| | | | | | 5250 | 21.7 | 14.98 | 54.05 | 0.2572 | 0.03825 |
| | | | | | 5500 | 22.0 | 15.43 | 56.41 | 0.2619 | 0.03831 |
| | | | | | 6000 | 22.8 | 16.29 | 61.11 | 0.2710 | 0.03843 |
| | | | | | 6500 | 23.5 | 17.10 | 65.78 | 0.2802 | 0.03855 |
| | | | | LT 245 75R 17 | 5000 | 19.9 | 15.55 | 43.04 | 0.2506 | 0.03743 |
| | | | | | 5250 | 20.2 | 16.09 | 44.99 | 0.2549 | 0.03746 |
| | | | | | 5500 | 20.5 | 16.61 | 46.94 | 0.2592 | 0.03748 |
| | | | | | 6000 | 21.1 | 17.61 | 50.82 | 0.2677 | 0.03754 |
| | | | | | 6500 | 21.7 | 18.55 | 54.68 | 0.2763 | 0.03759 |
| | | | | P 265 60R 18 | 5000 | 18.8 | 16.49 | 33.39 | 0.2983 | 0.03700 |
| | | | | | 5250 | 19.0 | 17.06 | 35.05 | 0.3053 | 0.03701 |
| | | | | | 5500 | 19.3 | 17.62 | 36.71 | 0.3123 | 0.03703 |
| | | | | | 6000 | 19.9 | 18.69 | 40.04 | 0.3265 | 0.03705 |
| | | | | | 6500 | 20.4 | 19.69 | 43.41 | 0.3408 | 0.03707 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5000 | 19.4 | 15.92 | 41.27 | 0.2186 | 0.03742 |
| | | | | | 5250 | 19.7 | 16.46 | 43.33 | 0.2218 | 0.03744 |
| | | | | | 5500 | 20.0 | 16.97 | 45.39 | 0.2250 | 0.03747 |
| | | | | | 6000 | 20.7 | 17.97 | 49.52 | 0.2314 | 0.03752 |
| | | | | | 6500 | 21.3 | 18.89 | 53.68 | 0.2379 | 0.03758 |
| | | | | P 275 55R 20 BSW | 5000 | 19.7 | 15.69 | 41.62 | 0.2631 | 0.03724 |
| | | | | | 5250 | 20.1 | 16.19 | 43.81 | 0.2691 | 0.03726 |
| | | | | | 5500 | 20.4 | 16.68 | 46.01 | 0.2750 | 0.03728 |
| | | | | | 6000 | 21.1 | 17.60 | 50.44 | 0.2870 | 0.03731 |
| | | | | | 6500 | 21.8 | 18.46 | 54.91 | 0.2992 | 0.03735 |
| | | | | P 265 70R 17 | 5000 | 19.4 | 15.99 | 37.03 | 0.2760 | 0.03772 |
| | | | | | 5250 | 19.6 | 16.54 | 38.79 | 0.2820 | 0.03777 |
| | | | | | 5500 | 19.9 | 17.08 | 40.55 | 0.2880 | 0.03781 |
| | | | | | 6000 | 20.5 | 18.10 | 44.08 | 0.2999 | 0.03790 |
| | | | | | 6500 | 21.1 | 19.06 | 47.62 | 0.3119 | 0.03798 |
| | | | | P 275 45R 22 | 5000 | 21.1 | 14.69 | 48.48 | 0.3312 | 0.03714 |
| | | | | | 5250 | 21.4 | 15.19 | 50.50 | 0.3388 | 0.03715 |
| | | | | | 5500 | 21.7 | 15.67 | 52.51 | 0.3464 | 0.03716 |
| | | | | | 6000 | 22.3 | 16.60 | 56.50 | 0.3615 | 0.03718 |
| | | | | | 6500 | 23.0 | 17.49 | 60.44 | 0.3764 | 0.03720 |
| | | | | P 275 65R 18 | 5000 | 18.6 | 16.67 | 33.45 | 0.2461 | 0.03742 |
| | | | | | 5250 | 18.8 | 17.24 | 35.19 | 0.2512 | 0.03745 |
| | | | | | 5500 | 19.1 | 17.80 | 36.94 | 0.2563 | 0.03748 |
| | | | | | 6000 | 19.7 | 18.86 | 40.47 | 0.2667 | 0.03754 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

**2013 F150 5.0L/6.2L**

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 6500 | 20.2 | 19.86 | 44.03 | 0.2771 | 0.03759 |
| F150 RCL | 5.0L | Auto | 4x2 | P 235 75R 17 | 5000 | 18.5 | 16.72 | 30.03 | 0.2722 | 0.03810 |
| | | | | | 5250 | 18.7 | 17.34 | 31.41 | 0.2776 | 0.03813 |
| | | | | | 5500 | 19.0 | 17.94 | 32.79 | 0.2830 | 0.03816 |
| | | | | | 6000 | 19.4 | 19.11 | 35.54 | 0.2938 | 0.03822 |
| | | | | | 6500 | 19.9 | 20.22 | 38.30 | 0.3046 | 0.03828 |
| | | | | P 255 65R 17 | 5000 | 19.6 | 15.82 | 36.71 | 0.2885 | 0.03824 |
| | | | | | 5250 | 19.8 | 16.37 | 38.43 | 0.2944 | 0.03828 |
| | | | | | 5500 | 20.1 | 16.91 | 40.14 | 0.3002 | 0.03832 |
| | | | | | 6000 | 20.7 | 17.94 | 43.57 | 0.3118 | 0.03841 |
| | | | | | 6500 | 21.3 | 18.92 | 47.01 | 0.3235 | 0.03849 |
| | | | | LT 275 65R 18 | 5000 | 21.5 | 14.35 | 51.69 | 0.2526 | 0.03889 |
| | | | | | 5250 | 21.9 | 14.82 | 54.05 | 0.2572 | 0.03895 |
| | | | | | 5500 | 22.3 | 15.27 | 56.41 | 0.2619 | 0.03901 |
| | | | | | 6000 | 23.0 | 16.13 | 61.11 | 0.2710 | 0.03913 |
| | | | | | 6500 | 23.7 | 16.93 | 65.78 | 0.2802 | 0.03925 |
| | | | | LT 245 75R 17 | 5000 | 20.1 | 15.37 | 43.04 | 0.2506 | 0.03813 |
| | | | | | 5250 | 20.4 | 15.91 | 44.99 | 0.2549 | 0.03816 |
| | | | | | 5500 | 20.7 | 16.42 | 46.94 | 0.2592 | 0.03818 |
| | | | | | 6000 | 21.3 | 17.41 | 50.82 | 0.2677 | 0.03824 |
| | | | | | 6500 | 21.9 | 18.35 | 54.68 | 0.2763 | 0.03829 |

# ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 5.0L/6.2L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Description | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | P 265 60R 18 | 5000 | 19.0 | 16.28 | 33.39 | 0.2983 | 0.03770 |
| | | | | | 5250 | 19.3 | 16.85 | 35.05 | 0.3053 | 0.03772 |
| | | | | | 5500 | 19.6 | 17.41 | 36.71 | 0.3123 | 0.03773 |
| | | | | | 6000 | 20.1 | 18.47 | 40.04 | 0.3265 | 0.03775 |
| | | | | | 6500 | 20.7 | 19.47 | 43.41 | 0.3408 | 0.03778 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5000 | 19.7 | 15.73 | 41.27 | 0.2186 | 0.03812 |
| | | | | | 5250 | 20.0 | 16.26 | 43.33 | 0.2218 | 0.03814 |
| | | | | | 5500 | 20.3 | 16.78 | 45.39 | 0.2250 | 0.03817 |
| | | | | | 6000 | 20.9 | 17.77 | 49.52 | 0.2314 | 0.03822 |
| | | | | | 6500 | 21.5 | 18.69 | 53.68 | 0.2379 | 0.03828 |
| | | | | P 275 55R 20 BSW | 5000 | 20.0 | 15.51 | 41.62 | 0.2631 | 0.03794 |
| | | | | | 5250 | 20.3 | 16.01 | 43.81 | 0.2691 | 0.03796 |
| | | | | | 5500 | 20.6 | 16.49 | 46.01 | 0.2750 | 0.03798 |
| | | | | | 6000 | 21.3 | 17.41 | 50.44 | 0.2870 | 0.03802 |
| | | | | | 6500 | 22.0 | 18.27 | 54.91 | 0.2992 | 0.03805 |
| | | | | P 265 70R 17 | 5000 | 19.6 | 15.80 | 37.03 | 0.2760 | 0.03842 |
| | | | | | 5250 | 19.9 | 16.35 | 38.79 | 0.2820 | 0.03847 |
| | | | | | 5500 | 20.2 | 16.88 | 40.55 | 0.2880 | 0.03851 |
| | | | | | 6000 | 20.7 | 17.89 | 44.08 | 0.2999 | 0.03860 |
| | | | | | 6500 | 21.3 | 18.86 | 47.62 | 0.3119 | 0.03868 |
| | | | | P 275 45R 22 | 5000 | 21.3 | 14.53 | 48.48 | 0.3312 | 0.03784 |
| | | | | | 5250 | 21.6 | 15.02 | 50.50 | 0.3388 | 0.03785 |
| | | | | | 5500 | 21.9 | 15.51 | 52.51 | 0.3464 | 0.03786 |
| | | | | | 6000 | 22.6 | 16.43 | 56.50 | 0.3615 | 0.03788 |
| | | | | | 6500 | 23.2 | 17.32 | 60.44 | 0.3764 | 0.03790 |
| | | | | P 275 65R 18 | 5000 | 18.8 | 16.46 | 33.45 | 0.2461 | 0.03812 |
| | | | | | 5250 | 19.1 | 17.03 | 35.19 | 0.2512 | 0.03815 |
| | | | | | 5500 | 19.4 | 17.58 | 36.94 | 0.2563 | 0.03818 |
| | | | | | 6000 | 19.9 | 18.64 | 40.47 | 0.2667 | 0.03824 |
| | | | | | 6500 | 20.5 | 19.63 | 44.03 | 0.2771 | 0.03829 |
| F150 All SC except 163" WB | 5.0L/6.2L | Auto | 4x2 | P 235 75R 17 | 5250 | 18.4 | 17.67 | 31.41 | 0.2776 | 0.03708 |
| | | | | | 5500 | 18.6 | 18.28 | 32.79 | 0.2830 | 0.03711 |
| | | | | | 6000 | 19.1 | 19.46 | 35.54 | 0.2938 | 0.03717 |
| | | | | | 6500 | 19.5 | 20.58 | 38.30 | 0.3046 | 0.03723 |
| | | | | | 7000 | 20.0 | 21.65 | 41.07 | 0.3154 | 0.03729 |
| | | | | P 255 65R 17 | 5250 | 19.5 | 16.66 | 38.43 | 0.2944 | 0.03723 |
| | | | | | 5500 | 19.8 | 17.21 | 40.14 | 0.3002 | 0.03727 |
| | | | | | 6000 | 20.3 | 18.25 | 43.57 | 0.3118 | 0.03736 |
| | | | | | 6500 | 20.9 | 19.23 | 47.01 | 0.3235 | 0.03744 |
| | | | | | 7000 | 21.5 | 20.16 | 50.45 | 0.3352 | 0.03753 |
| | | | | LT 275 65R 18 | 5250 | 21.6 | 15.06 | 54.05 | 0.2572 | 0.03790 |
| | | | | | 5500 | 21.9 | 15.51 | 56.41 | 0.2619 | 0.03796 |
| | | | | | 6000 | 22.6 | 16.37 | 61.11 | 0.2710 | 0.03808 |
| | | | | | 6500 | 23.4 | 17.19 | 65.78 | 0.2802 | 0.03820 |
| | | | | | 7000 | 24.1 | 17.95 | 70.44 | 0.2893 | 0.03832 |
| | | | | LT 245 75R 17 | 5250 | 20.1 | 16.18 | 44.99 | 0.2549 | 0.03711 |
| | | | | | 5500 | 20.4 | 16.70 | 46.94 | 0.2592 | 0.03713 |
| | | | | | 6000 | 21.0 | 17.70 | 50.82 | 0.2677 | 0.03719 |
| | | | | | 6500 | 21.5 | 18.65 | 54.68 | 0.2763 | 0.03724 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 5.0L/6.2L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients 3-Term | | f0 | f1 | f2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 7000 | 22.1 | 19.55 | 58.53 | 0.2848 | 0.03729 |
| | | | | P 265 60R 18 | 5250 | 18.9 | 17.17 | 35.05 | 0.3053 | 0.03666 |
| | | | | | 5500 | 19.2 | 17.72 | 36.71 | 0.3123 | 0.03668 |
| | | | | | 6000 | 19.7 | 18.80 | 40.04 | 0.3265 | 0.03670 |
| | | | | | 6500 | 20.3 | 19.81 | 43.41 | 0.3408 | 0.03672 |
| | | | | | 7000 | 20.9 | 20.76 | 46.79 | 0.3552 | 0.03675 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5250 | 19.6 | 16.55 | 43.33 | 0.2218 | 0.03709 |
| | | | | | 5500 | 19.9 | 17.07 | 45.39 | 0.2250 | 0.03712 |
| | | | | | 6000 | 20.5 | 18.07 | 49.52 | 0.2314 | 0.03717 |
| | | | | | 6500 | 21.2 | 19.00 | 53.68 | 0.2379 | 0.03723 |
| | | | | | 7000 | 21.8 | 19.88 | 57.85 | 0.2444 | 0.03728 |
| | | | | P 275 55R 20 BSW | 5250 | 19.9 | 16.29 | 43.81 | 0.2691 | 0.03691 |
| | | | | | 5500 | 20.3 | 16.78 | 46.01 | 0.2750 | 0.03693 |
| | | | | | 6000 | 21.0 | 17.70 | 50.44 | 0.2870 | 0.03696 |
| | | | | | 6500 | 21.6 | 18.56 | 54.91 | 0.2992 | 0.03700 |
| | | | | | 7000 | 22.3 | 19.36 | 59.42 | 0.3114 | 0.03704 |
| | | | | P 265 70R 17 | 5250 | 19.5 | 16.64 | 38.79 | 0.2820 | 0.03742 |
| | | | | | 5500 | 19.8 | 17.18 | 40.55 | 0.2880 | 0.03746 |
| | | | | | 6000 | 20.4 | 18.20 | 44.08 | 0.2999 | 0.03755 |
| | | | | | 6500 | 21.0 | 19.17 | 47.62 | 0.3119 | 0.03763 |
| | | | | | 7000 | 21.6 | 20.08 | 51.16 | 0.3239 | 0.03772 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 5.0L/6.2L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Description | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | P 275 45R 22 | 5250 | 21.3 | 15.27 | 50.50 | 0.3388 | 0.03680 |
| | | | | | 5500 | 21.6 | 15.76 | 52.51 | 0.3464 | 0.03681 |
| | | | | | 6000 | 22.2 | 16.69 | 56.50 | 0.3615 | 0.03683 |
| | | | | | 6500 | 22.9 | 17.58 | 60.44 | 0.3764 | 0.03685 |
| | | | | | 7000 | 23.5 | 18.43 | 64.35 | 0.3911 | 0.03686 |
| | | | | P 275 65R 18 | 5250 | 18.7 | 17.35 | 35.19 | 0.2512 | 0.03710 |
| | | | | | 5500 | 19.0 | 17.91 | 36.94 | 0.2563 | 0.03713 |
| | | | | | 6000 | 19.6 | 18.97 | 40.47 | 0.2667 | 0.03719 |
| | | | | | 6500 | 20.1 | 19.97 | 44.03 | 0.2771 | 0.03724 |
| | | | | | 7000 | 20.7 | 20.91 | 47.63 | 0.2876 | 0.03730 |
| F150 SC w/163" WB | 5.0L/6.2L | Auto | 4x2 | P 235 75R 17 | 5250 | 18.7 | 17.42 | 31.41 | 0.2776 | 0.03787 |
| | | | | | 5500 | 18.9 | 18.02 | 32.79 | 0.2830 | 0.03790 |
| | | | | | 6000 | 19.4 | 19.19 | 35.54 | 0.2938 | 0.03796 |
| | | | | | 6500 | 19.8 | 20.31 | 38.30 | 0.3046 | 0.03802 |
| | | | | | 7000 | 20.3 | 21.37 | 41.07 | 0.3154 | 0.03808 |
| | | | | P 255 65R 17 | 5250 | 19.8 | 16.44 | 38.43 | 0.2944 | 0.03802 |
| | | | | | 5500 | 20.0 | 16.98 | 40.14 | 0.3002 | 0.03806 |
| | | | | | 6000 | 20.6 | 18.01 | 43.57 | 0.3118 | 0.03815 |
| | | | | | 6500 | 21.2 | 18.99 | 47.01 | 0.3235 | 0.03823 |
| | | | | | 7000 | 21.7 | 19.92 | 50.45 | 0.3352 | 0.03832 |
| | | | | LT 275 65R 18 | 5250 | 21.8 | 14.88 | 54.05 | 0.2572 | 0.03869 |
| | | | | | 5500 | 22.2 | 15.33 | 56.41 | 0.2619 | 0.03875 |
| | | | | | 6000 | 22.9 | 16.19 | 61.11 | 0.2710 | 0.03887 |
| | | | | | 6500 | 23.6 | 16.99 | 65.78 | 0.2802 | 0.03899 |
| | | | | | 7000 | 24.4 | 17.76 | 70.44 | 0.2893 | 0.03911 |
| | | | | LT 245 75R 17 | 5250 | 20.3 | 15.98 | 44.99 | 0.2549 | 0.03789 |
| | | | | | 5500 | 20.6 | 16.49 | 46.94 | 0.2592 | 0.03792 |
| | | | | | 6000 | 21.2 | 17.48 | 50.82 | 0.2677 | 0.03798 |
| | | | | | 6500 | 21.8 | 18.43 | 54.68 | 0.2763 | 0.03803 |
| | | | | | 7000 | 22.4 | 19.32 | 58.53 | 0.2848 | 0.03808 |
| | | | | P 265 60R 18 | 5250 | 19.2 | 16.93 | 35.05 | 0.3053 | 0.03745 |
| | | | | | 5500 | 19.5 | 17.49 | 36.71 | 0.3123 | 0.03746 |
| | | | | | 6000 | 20.0 | 18.55 | 40.04 | 0.3265 | 0.03749 |
| | | | | | 6500 | 20.6 | 19.55 | 43.41 | 0.3408 | 0.03751 |
| | | | | | 7000 | 21.1 | 20.50 | 46.79 | 0.3552 | 0.03754 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5250 | 19.9 | 16.34 | 43.33 | 0.2218 | 0.03788 |
| | | | | | 5500 | 20.2 | 16.85 | 45.39 | 0.2250 | 0.03791 |
| | | | | | 6000 | 20.8 | 17.84 | 49.52 | 0.2314 | 0.03796 |
| | | | | | 6500 | 21.4 | 18.77 | 53.68 | 0.2379 | 0.03802 |
| | | | | | 7000 | 22.0 | 19.64 | 57.85 | 0.2444 | 0.03807 |
| | | | | P 275 55R 20 BSW | 5250 | 20.2 | 16.08 | 43.81 | 0.2691 | 0.03770 |
| | | | | | 5500 | 20.5 | 16.56 | 46.01 | 0.2750 | 0.03772 |
| | | | | | 6000 | 21.2 | 17.48 | 50.44 | 0.2870 | 0.03775 |
| | | | | | 6500 | 21.9 | 18.34 | 54.91 | 0.2992 | 0.03779 |
| | | | | | 7000 | 22.6 | 19.14 | 59.42 | 0.3114 | 0.03783 |
| | | | | P 265 70R 17 | 5250 | 19.8 | 16.42 | 38.79 | 0.2820 | 0.03820 |
| | | | | | 5500 | 20.1 | 16.95 | 40.55 | 0.2880 | 0.03825 |
| | | | | | 6000 | 20.7 | 17.97 | 44.08 | 0.2999 | 0.03833 |
| | | | | | 6500 | 21.2 | 18.93 | 47.62 | 0.3119 | 0.03842 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 F150 5.0L/6.2L*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients 3-Term | | f0 | f1 | f2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 7000 | 21.8 | 19.84 | 51.16 | 0.3239 | 0.03851 |
| | | | | P 275 45R 22 | 5250 | 21.5 | 15.09 | 50.50 | 0.3388 | 0.03758 |
| | | | | | 5500 | 21.8 | 15.57 | 52.51 | 0.3464 | 0.03759 |
| | | | | | 6000 | 22.5 | 16.50 | 56.50 | 0.3615 | 0.03761 |
| | | | | | 6500 | 23.1 | 17.38 | 60.44 | 0.3764 | 0.03763 |
| | | | | | 7000 | 23.7 | 18.22 | 64.35 | 0.3911 | 0.03765 |
| | | | | P 275 65R 18 | 5250 | 19.0 | 17.11 | 35.19 | 0.2512 | 0.03789 |
| | | | | | 5500 | 19.3 | 17.66 | 36.94 | 0.2563 | 0.03792 |
| | | | | | 6000 | 19.8 | 18.72 | 40.47 | 0.2667 | 0.03797 |
| | | | | | 6500 | 20.4 | 19.72 | 44.03 | 0.2771 | 0.03803 |
| | | | | | 7000 | 21.0 | 20.65 | 47.63 | 0.2876 | 0.03809 |
| F150 All CC | 5.0L/6.2L | Auto | 4x2 | P 235 75R 17 | 5500 | 18.4 | 18.47 | 32.79 | 0.2830 | 0.03653 |
| | | | | | 6000 | 18.9 | 19.66 | 35.54 | 0.2938 | 0.03659 |
| | | | | | 6500 | 19.4 | 20.78 | 38.30 | 0.3046 | 0.03665 |
| | | | | P 255 65R 17 | 5500 | 19.6 | 17.38 | 40.14 | 0.3002 | 0.03669 |
| | | | | | 6000 | 20.1 | 18.42 | 43.57 | 0.3118 | 0.03677 |
| | | | | | 6500 | 20.7 | 19.41 | 47.01 | 0.3235 | 0.03686 |
| | | | | LT 275 65R 18 | 5500 | 21.7 | 15.65 | 56.41 | 0.2619 | 0.03738 |
| | | | | | 6000 | 22.5 | 16.51 | 61.11 | 0.2710 | 0.03750 |
| | | | | | 6500 | 23.2 | 17.33 | 65.78 | 0.2802 | 0.03762 |
| | | | | LT 245 75R 17 | 5500 | 20.2 | 16.86 | 46.94 | 0.2592 | 0.03655 |
| | | | | | 6000 | 20.8 | 17.87 | 50.82 | 0.2677 | 0.03660 |
| | | | | | 6500 | 21.4 | 18.82 | 54.68 | 0.2763 | 0.03666 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 F150 5.0L/6.2L*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Description | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | P 265 60R 18 | 5500 | 19.0 | 17.91 | 36.71 | 0.3123 | 0.03609 |
| | | | | | 6000 | 19.6 | 18.98 | 40.04 | 0.3265 | 0.03612 |
| | | | | | 6500 | 20.1 | 20.00 | 43.41 | 0.3408 | 0.03614 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5500 | 19.7 | 17.24 | 45.39 | 0.2250 | 0.03654 |
| | | | | | 6000 | 20.3 | 18.24 | 49.52 | 0.2314 | 0.03659 |
| | | | | | 6500 | 21.0 | 19.18 | 53.68 | 0.2379 | 0.03664 |
| | | | | P 275 55R 20 BSW | 5500 | 20.1 | 16.94 | 46.01 | 0.2750 | 0.03634 |
| | | | | | 6000 | 20.8 | 17.87 | 50.44 | 0.2870 | 0.03638 |
| | | | | | 6500 | 21.5 | 18.73 | 54.91 | 0.2992 | 0.03642 |
| | | | | P 265 70R 17 | 5500 | 19.6 | 17.35 | 40.55 | 0.2880 | 0.03687 |
| | | | | | 6000 | 20.2 | 18.38 | 44.08 | 0.2999 | 0.03696 |
| | | | | | 6500 | 20.8 | 19.35 | 47.62 | 0.3119 | 0.03705 |
| | | | | P 275 45R 22 | 5500 | 21.4 | 15.90 | 52.51 | 0.3464 | 0.03622 |
| | | | | | 6000 | 22.0 | 16.84 | 56.50 | 0.3615 | 0.03624 |
| | | | | | 6500 | 22.7 | 17.73 | 60.44 | 0.3764 | 0.03626 |
| | | | | P 275 65R 18 | 5500 | 18.8 | 18.09 | 36.94 | 0.2563 | 0.03654 |
| | | | | | 6000 | 19.4 | 19.16 | 40.47 | 0.2667 | 0.03660 |
| | | | | | 6500 | 19.9 | 20.17 | 44.03 | 0.2771 | 0.03666 |
| F150 RCS | 5.0L | Auto | 4x4 | P 235 75R 17 | 5250 | 19.9 | 16.35 | 32.25 | 0.3946 | 0.03886 |
| | | | | | 5500 | 20.1 | 16.93 | 33.62 | 0.4000 | 0.03889 |
| | | | | | 6000 | 20.6 | 18.05 | 36.38 | 0.4108 | 0.03895 |
| | | | | | 6500 | 21.0 | 19.13 | 39.14 | 0.4216 | 0.03901 |
| | | | | | 7000 | 21.5 | 20.15 | 41.90 | 0.4324 | 0.03907 |
| | | | | P 265 70R 17 | 5250 | 21.0 | 15.49 | 39.62 | 0.3952 | 0.03916 |
| | | | | | 5500 | 21.3 | 16.01 | 41.38 | 0.4012 | 0.03920 |
| | | | | | 6000 | 21.8 | 17.00 | 44.91 | 0.4131 | 0.03929 |
| | | | | | 6500 | 22.4 | 17.94 | 48.44 | 0.4251 | 0.03937 |
| | | | | | 7000 | 23.0 | 18.82 | 51.98 | 0.4371 | 0.03946 |
| | | | | LT 245 75R 17 | 5250 | 21.5 | 15.09 | 45.82 | 0.3688 | 0.03885 |
| | | | | | 5500 | 21.8 | 15.59 | 47.76 | 0.3731 | 0.03888 |
| | | | | | 6000 | 22.4 | 16.56 | 51.64 | 0.3816 | 0.03894 |
| | | | | | 6500 | 23.0 | 17.47 | 55.51 | 0.3902 | 0.03899 |
| | | | | | 7000 | 23.6 | 18.35 | 59.36 | 0.3986 | 0.03904 |
| | | | | P 275 65R 18 | 5250 | 20.2 | 16.12 | 36.01 | 0.3621 | 0.03882 |
| | | | | | 5500 | 20.4 | 16.66 | 37.76 | 0.3672 | 0.03885 |
| | | | | | 6000 | 21.0 | 17.69 | 41.29 | 0.3775 | 0.03891 |
| | | | | | 6500 | 21.6 | 18.66 | 44.85 | 0.3879 | 0.03896 |
| | | | | | 7000 | 22.1 | 19.57 | 48.45 | 0.3985 | 0.03902 |
| | | | | LT 275 65R 18 | 5250 | 23.0 | 14.13 | 54.87 | 0.3681 | 0.03962 |
| | | | | | 5500 | 23.3 | 14.57 | 57.23 | 0.3727 | 0.03968 |
| | | | | | 6000 | 24.1 | 15.41 | 61.92 | 0.3819 | 0.03981 |
| | | | | | 6500 | 24.8 | 16.20 | 66.60 | 0.3910 | 0.03993 |
| | | | | | 7000 | 25.5 | 16.95 | 71.25 | 0.4002 | 0.04005 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5250 | 21.0 | 15.43 | 44.15 | 0.3334 | 0.03882 |
| | | | | | 5500 | 21.4 | 15.93 | 46.21 | 0.3366 | 0.03885 |
| | | | | | 6000 | 22.0 | 16.89 | 50.34 | 0.3431 | 0.03890 |
| | | | | | 6500 | 22.6 | 17.80 | 54.50 | 0.3496 | 0.03896 |
| | | | | | 7000 | 23.2 | 18.65 | 58.67 | 0.3561 | 0.03901 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 5.0L/6.2L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | P 275 55R 20 AT | 5250 | 22.8 | 14.21 | 55.65 | 0.3719 | 0.03883 |
| | | | | | 5500 | 23.2 | 14.64 | 58.24 | 0.3769 | 0.03885 |
| | | | | | 6000 | 24.0 | 15.44 | 63.44 | 0.3871 | 0.03891 |
| | | | | | 6500 | 24.8 | 16.20 | 68.65 | 0.3973 | 0.03896 |
| | | | | | 7000 | 25.6 | 16.91 | 73.87 | 0.4075 | 0.03901 |
| | | | | P 275 55R 20 BSW | 5250 | 21.4 | 15.20 | 44.63 | 0.3807 | 0.03864 |
| | | | | | 5500 | 21.7 | 15.67 | 46.83 | 0.3867 | 0.03866 |
| | | | | | 6000 | 22.4 | 16.57 | 51.26 | 0.3987 | 0.03869 |
| | | | | | 6500 | 23.1 | 17.41 | 55.73 | 0.4108 | 0.03873 |
| | | | | | 7000 | 23.8 | 18.20 | 60.24 | 0.4231 | 0.03877 |
| | | | | P 275 45R 22 | 5250 | 22.7 | 14.30 | 51.32 | 0.4513 | 0.03853 |
| | | | | | 5500 | 23.0 | 14.77 | 53.33 | 0.4589 | 0.03854 |
| | | | | | 6000 | 23.7 | 15.68 | 57.32 | 0.4740 | 0.03856 |
| | | | | | 6500 | 24.3 | 16.54 | 61.26 | 0.4889 | 0.03858 |
| | | | | | 7000 | 24.9 | 17.36 | 65.17 | 0.5036 | 0.03860 |
| | | | | P 255 65R 17 | 5250 | 21.0 | 15.45 | 39.27 | 0.4161 | 0.03905 |
| | | | | | 5500 | 21.3 | 15.97 | 40.99 | 0.4219 | 0.03909 |
| | | | | | 6000 | 21.9 | 16.97 | 44.42 | 0.4335 | 0.03917 |
| | | | | | 6500 | 22.4 | 17.92 | 47.86 | 0.4452 | 0.03926 |
| | | | | | 7000 | 23.0 | 18.82 | 51.30 | 0.4569 | 0.03934 |
| F150 RCL | 5.0L | Auto | 4x4 | P 235 75R 17 | 5250 | 20.1 | 16.18 | 32.25 | 0.3946 | 0.03948 |
| | | | | | 5500 | 20.3 | 16.76 | 33.62 | 0.4000 | 0.03951 |
| | | | | | 6000 | 20.8 | 17.87 | 36.38 | 0.4108 | 0.03957 |
| | | | | | 6500 | 21.2 | 18.94 | 39.14 | 0.4216 | 0.03963 |
| | | | | | 7000 | 21.7 | 19.96 | 41.90 | 0.4324 | 0.03969 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 F150 5.0L/6.2L*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients 3-Term | | f0 | f1 | f2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | P 265 70R 17 | 5250 | 21.2 | 15.34 | 39.62 | 0.3952 | 0.03978 |
| | | | | | 5500 | 21.5 | 15.85 | 41.38 | 0.4012 | 0.03982 |
| | | | | | 6000 | 22.0 | 16.84 | 44.91 | 0.4131 | 0.03991 |
| | | | | | 6500 | 22.6 | 17.77 | 48.44 | 0.4251 | 0.03999 |
| | | | | | 7000 | 23.2 | 18.66 | 51.98 | 0.4371 | 0.04008 |
| | | | | LT 245 75R 17 | 5250 | 21.7 | 14.95 | 45.82 | 0.3688 | 0.03948 |
| | | | | | 5500 | 22.0 | 15.45 | 47.76 | 0.3731 | 0.03950 |
| | | | | | 6000 | 22.6 | 16.41 | 51.64 | 0.3816 | 0.03956 |
| | | | | | 6500 | 23.2 | 17.32 | 55.51 | 0.3902 | 0.03961 |
| | | | | | 7000 | 23.8 | 18.19 | 59.36 | 0.3986 | 0.03966 |
| | | | | P 275 65R 18 | 5250 | 20.4 | 15.96 | 36.01 | 0.3621 | 0.03944 |
| | | | | | 5500 | 20.6 | 16.49 | 37.76 | 0.3672 | 0.03947 |
| | | | | | 6000 | 21.2 | 17.51 | 41.29 | 0.3775 | 0.03953 |
| | | | | | 6500 | 21.8 | 18.48 | 44.85 | 0.3879 | 0.03958 |
| | | | | | 7000 | 22.3 | 19.39 | 48.45 | 0.3985 | 0.03964 |
| | | | | LT 275 65R 18 | 5250 | 23.2 | 14.00 | 54.87 | 0.3681 | 0.04024 |
| | | | | | 5500 | 23.5 | 14.44 | 57.23 | 0.3727 | 0.04030 |
| | | | | | 6000 | 24.3 | 15.28 | 61.92 | 0.3819 | 0.04043 |
| | | | | | 6500 | 25.0 | 16.07 | 66.60 | 0.3910 | 0.04055 |
| | | | | | 7000 | 25.7 | 16.81 | 71.25 | 0.4002 | 0.04067 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5250 | 21.3 | 15.28 | 44.15 | 0.3334 | 0.03944 |
| | | | | | 5500 | 21.6 | 15.78 | 46.21 | 0.3366 | 0.03947 |
| | | | | | 6000 | 22.2 | 16.74 | 50.34 | 0.3431 | 0.03952 |
| | | | | | 6500 | 22.8 | 17.63 | 54.50 | 0.3496 | 0.03958 |
| | | | | | 7000 | 23.4 | 18.49 | 58.67 | 0.3561 | 0.03963 |
| | | | | P 275 55R 20 AT | 5250 | 23.0 | 14.08 | 55.65 | 0.3719 | 0.03945 |
| | | | | | 5500 | 23.4 | 14.51 | 58.24 | 0.3769 | 0.03947 |
| | | | | | 6000 | 24.2 | 15.31 | 63.44 | 0.3871 | 0.03953 |
| | | | | | 6500 | 25.0 | 16.07 | 68.65 | 0.3973 | 0.03958 |
| | | | | | 7000 | 25.8 | 16.78 | 73.87 | 0.4075 | 0.03963 |
| | | | | P 275 55R 20 BSW | 5250 | 21.6 | 15.05 | 44.63 | 0.3807 | 0.03926 |
| | | | | | 5500 | 21.9 | 15.52 | 46.83 | 0.3867 | 0.03928 |
| | | | | | 6000 | 22.6 | 16.42 | 51.26 | 0.3987 | 0.03931 |
| | | | | | 6500 | 23.3 | 17.26 | 55.73 | 0.4108 | 0.03935 |
| | | | | | 7000 | 24.0 | 18.04 | 60.24 | 0.4231 | 0.03939 |
| | | | | P 275 45R 22 | 5250 | 22.9 | 14.18 | 51.32 | 0.4513 | 0.03915 |
| | | | | | 5500 | 23.2 | 14.64 | 53.33 | 0.4589 | 0.03916 |
| | | | | | 6000 | 23.9 | 15.54 | 57.32 | 0.4740 | 0.03918 |
| | | | | | 6500 | 24.5 | 16.40 | 61.26 | 0.4889 | 0.03920 |
| | | | | | 7000 | 25.1 | 17.22 | 65.17 | 0.5036 | 0.03922 |
| | | | | P 255 65R 17 | 5250 | 21.2 | 15.30 | 39.27 | 0.4161 | 0.03967 |
| | | | | | 5500 | 21.5 | 15.82 | 40.99 | 0.4219 | 0.03971 |
| | | | | | 6000 | 22.1 | 16.81 | 44.42 | 0.4335 | 0.03979 |
| | | | | | 6500 | 22.6 | 17.76 | 47.86 | 0.4452 | 0.03988 |
| | | | | | 7000 | 23.2 | 18.66 | 51.30 | 0.4569 | 0.03996 |
| F150 All SC except 163" WB | 5.0L/6.2L | Auto | 4x4 | P 235 75R 17 | 5500 | 20.3 | 16.74 | 33.62 | 0.4000 | 0.03957 |
| | | | | | 6000 | 20.8 | 17.86 | 36.38 | 0.4108 | 0.03963 |
| | | | | | 6500 | 21.3 | 18.92 | 39.14 | 0.4216 | 0.03969 |
| | | | | | 7000 | 21.7 | 19.94 | 41.90 | 0.4324 | 0.03975 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 5.0L/6.2L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 7500 | 22.2 | 20.92 | 44.67 | 0.4432 | 0.03981 |
| | | | | P 265 70R 17 | 5500 | 21.5 | 15.84 | 41.38 | 0.4012 | 0.03988 |
| | | | | | 6000 | 22.1 | 16.82 | 44.91 | 0.4131 | 0.03997 |
| | | | | | 6500 | 22.6 | 17.76 | 48.44 | 0.4251 | 0.04005 |
| | | | | | 7000 | 23.2 | 18.64 | 51.98 | 0.4371 | 0.04014 |
| | | | | | 7500 | 23.8 | 19.48 | 55.53 | 0.4491 | 0.04023 |
| | | | | LT 245 75R 17 | 5500 | 22.0 | 15.43 | 47.76 | 0.3731 | 0.03956 |
| | | | | | 6000 | 22.6 | 16.39 | 51.64 | 0.3816 | 0.03961 |
| | | | | | 6500 | 23.2 | 17.30 | 55.51 | 0.3902 | 0.03967 |
| | | | | | 7000 | 23.8 | 18.17 | 59.36 | 0.3986 | 0.03972 |
| | | | | | 7500 | 24.4 | 19.00 | 63.20 | 0.4071 | 0.03977 |
| | | | | P 275 65R 18 | 5500 | 20.7 | 16.48 | 37.76 | 0.3672 | 0.03953 |
| | | | | | 6000 | 21.2 | 17.50 | 41.29 | 0.3775 | 0.03959 |
| | | | | | 6500 | 21.8 | 18.46 | 44.85 | 0.3879 | 0.03964 |
| | | | | | 7000 | 22.4 | 19.37 | 48.45 | 0.3985 | 0.03970 |
| | | | | | 7500 | 22.9 | 20.23 | 52.07 | 0.4091 | 0.03976 |
| | | | | LT 275 65R 18 | 5500 | 23.6 | 14.43 | 57.23 | 0.3727 | 0.04036 |
| | | | | | 6000 | 24.3 | 15.27 | 61.92 | 0.3819 | 0.04048 |
| | | | | | 6500 | 25.0 | 16.06 | 66.60 | 0.3910 | 0.04060 |
| | | | | | 7000 | 25.7 | 16.80 | 71.25 | 0.4002 | 0.04072 |
| | | | | | 7500 | 26.5 | 17.51 | 75.89 | 0.4092 | 0.04084 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5500 | 21.6 | 15.76 | 46.21 | 0.3366 | 0.03953 |
| | | | | | 6000 | 22.2 | 16.72 | 50.34 | 0.3431 | 0.03958 |
| | | | | | 6500 | 22.8 | 17.62 | 54.50 | 0.3496 | 0.03964 |
| | | | | | 7000 | 23.4 | 18.47 | 58.67 | 0.3561 | 0.03969 |
| | | | | | 7500 | 24.0 | 19.28 | 62.85 | 0.3626 | 0.03974 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 F150 5.0L/6.2L*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | P 275 55R 20 AT | 5500 | 23.5 | 14.50 | 58.24 | 0.3769 | 0.03953 |
| | | | | | 6000 | 24.2 | 15.30 | 63.44 | 0.3871 | 0.03959 |
| | | | | | 6500 | 25.0 | 16.06 | 68.65 | 0.3973 | 0.03964 |
| | | | | | 7000 | 25.8 | 16.77 | 73.87 | 0.4075 | 0.03969 |
| | | | | | 7500 | 26.6 | 17.43 | 79.10 | 0.4178 | 0.03974 |
| | | | | P 275 55R 20 BSW | 5500 | 21.9 | 15.51 | 46.83 | 0.3867 | 0.03934 |
| | | | | | 6000 | 22.6 | 16.41 | 51.26 | 0.3987 | 0.03937 |
| | | | | | 6500 | 23.3 | 17.24 | 55.73 | 0.4108 | 0.03941 |
| | | | | | 7000 | 24.0 | 18.03 | 60.24 | 0.4231 | 0.03945 |
| | | | | | 7500 | 24.7 | 18.77 | 64.78 | 0.4354 | 0.03948 |
| | | | | P 275 45R 22 | 5500 | 23.2 | 14.63 | 53.33 | 0.4589 | 0.03922 |
| | | | | | 6000 | 23.9 | 15.53 | 57.32 | 0.4740 | 0.03924 |
| | | | | | 6500 | 24.5 | 16.39 | 61.26 | 0.4889 | 0.03926 |
| | | | | | 7000 | 25.1 | 17.21 | 65.17 | 0.5036 | 0.03928 |
| | | | | | 7500 | 25.8 | 17.99 | 69.04 | 0.5182 | 0.03930 |
| | | | | P 255 65R 17 | 5500 | 21.5 | 15.80 | 40.99 | 0.4219 | 0.03977 |
| | | | | | 6000 | 22.1 | 16.80 | 44.42 | 0.4335 | 0.03985 |
| | | | | | 6500 | 22.7 | 17.74 | 47.86 | 0.4452 | 0.03994 |
| | | | | | 7000 | 23.2 | 18.64 | 51.30 | 0.4569 | 0.04002 |
| | | | | | 7500 | 23.8 | 19.49 | 54.74 | 0.4685 | 0.04011 |
| F150 SC w/163" WB | 5.0L/6.2L | Auto | 4x4 | P 235 75R 17 | 5500 | 20.6 | 16.50 | 33.62 | 0.4000 | 0.04046 |
| | | | | | 6000 | 21.1 | 17.61 | 36.38 | 0.4108 | 0.04052 |
| | | | | | 6500 | 21.6 | 18.66 | 39.14 | 0.4216 | 0.04058 |
| | | | | | 7000 | 22.0 | 19.68 | 41.90 | 0.4324 | 0.04064 |
| | | | | | 7500 | 22.5 | 20.64 | 44.67 | 0.4432 | 0.04070 |
| | | | | P 265 70R 17 | 5500 | 21.8 | 15.63 | 41.38 | 0.4012 | 0.04077 |
| | | | | | 6000 | 22.4 | 16.60 | 44.91 | 0.4131 | 0.04086 |
| | | | | | 6500 | 22.9 | 17.53 | 48.44 | 0.4251 | 0.04095 |
| | | | | | 7000 | 23.5 | 18.41 | 51.98 | 0.4371 | 0.04103 |
| | | | | | 7500 | 24.1 | 19.24 | 55.53 | 0.4491 | 0.04112 |
| | | | | LT 245 75R 17 | 5500 | 22.3 | 15.23 | 47.76 | 0.3731 | 0.04045 |
| | | | | | 6000 | 22.9 | 16.18 | 51.64 | 0.3816 | 0.04051 |
| | | | | | 6500 | 23.5 | 17.09 | 55.51 | 0.3902 | 0.04056 |
| | | | | | 7000 | 24.1 | 17.95 | 59.36 | 0.3986 | 0.04061 |
| | | | | | 7500 | 24.7 | 18.77 | 63.20 | 0.4071 | 0.04067 |
| | | | | P 275 65R 18 | 5500 | 21.0 | 16.24 | 37.76 | 0.3672 | 0.04042 |
| | | | | | 6000 | 21.5 | 17.26 | 41.29 | 0.3775 | 0.04048 |
| | | | | | 6500 | 22.1 | 18.21 | 44.85 | 0.3879 | 0.04054 |
| | | | | | 7000 | 22.6 | 19.12 | 48.45 | 0.3985 | 0.04059 |
| | | | | | 7500 | 23.2 | 19.98 | 52.07 | 0.4091 | 0.04065 |
| | | | | LT 275 65R 18 | 5500 | 23.9 | 14.25 | 57.23 | 0.3727 | 0.04126 |
| | | | | | 6000 | 24.6 | 15.08 | 61.92 | 0.3819 | 0.04138 |
| | | | | | 6500 | 25.3 | 15.87 | 66.60 | 0.3910 | 0.04150 |
| | | | | | 7000 | 26.0 | 16.61 | 71.25 | 0.4002 | 0.04162 |
| | | | | | 7500 | 26.8 | 17.32 | 75.89 | 0.4092 | 0.04174 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5500 | 21.9 | 15.55 | 46.21 | 0.3366 | 0.04042 |
| | | | | | 6000 | 22.5 | 16.50 | 50.34 | 0.3431 | 0.04048 |
| | | | | | 6500 | 23.1 | 17.39 | 54.50 | 0.3496 | 0.04053 |
| | | | | | 7000 | 23.7 | 18.24 | 58.67 | 0.3561 | 0.04058 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

***2013 F150 5.0L/6.2L***

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 7500 | 24.3 | 19.04 | 62.85 | 0.3626 | 0.04064 |
| | | | | P 275 55R 20 AT | 5500 | 23.8 | 14.31 | 58.24 | 0.3769 | 0.04043 |
| | | | | | 6000 | 24.5 | 15.12 | 63.44 | 0.3871 | 0.04048 |
| | | | | | 6500 | 25.3 | 15.87 | 68.65 | 0.3973 | 0.04053 |
| | | | | | 7000 | 26.1 | 16.58 | 73.87 | 0.4075 | 0.04058 |
| | | | | | 7500 | 26.9 | 17.24 | 79.10 | 0.4178 | 0.04064 |
| | | | | P 275 55R 20 BSW | 5500 | 22.2 | 15.30 | 46.83 | 0.3867 | 0.04023 |
| | | | | | 6000 | 22.9 | 16.19 | 51.26 | 0.3987 | 0.04027 |
| | | | | | 6500 | 23.6 | 17.03 | 55.73 | 0.4108 | 0.04030 |
| | | | | | 7000 | 24.3 | 17.81 | 60.24 | 0.4231 | 0.04034 |
| | | | | | 7500 | 25.0 | 18.54 | 64.78 | 0.4354 | 0.04038 |
| | | | | P 275 45R 22 | 5500 | 23.5 | 14.45 | 53.33 | 0.4589 | 0.04011 |
| | | | | | 6000 | 24.2 | 15.34 | 57.32 | 0.4740 | 0.04013 |
| | | | | | 6500 | 24.8 | 16.19 | 61.26 | 0.4889 | 0.04015 |
| | | | | | 7000 | 25.4 | 17.01 | 65.17 | 0.5036 | 0.04017 |
| | | | | | 7500 | 26.1 | 17.79 | 69.04 | 0.5182 | 0.04019 |
| | | | | P 255 65R 17 | 5500 | 21.8 | 15.59 | 40.99 | 0.4219 | 0.04066 |
| | | | | | 6000 | 22.4 | 16.58 | 44.42 | 0.4335 | 0.04075 |
| | | | | | 6500 | 23.0 | 17.51 | 47.86 | 0.4452 | 0.04083 |
| | | | | | 7000 | 23.5 | 18.40 | 51.30 | 0.4569 | 0.04092 |
| | | | | | 7500 | 24.1 | 19.25 | 54.74 | 0.4685 | 0.04100 |
| F150 All CC | 5.0L/6.2L | Auto | 4x4 | P 235 75R 17 | 5500 | 20.0 | 16.99 | 33.62 | 0.4000 | 0.03867 |
| | | | | | 6000 | 20.5 | 18.12 | 36.38 | 0.4108 | 0.03873 |
| | | | | | 6500 | 21.0 | 19.19 | 39.14 | 0.4216 | 0.03879 |
| | | | | | 7000 | 21.4 | 20.22 | 41.90 | 0.4324 | 0.03885 |
| | | | | | 7500 | 21.9 | 21.21 | 44.67 | 0.4432 | 0.03891 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 F150 5.0L/6.2L*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart3.xls | 7/12/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add new 20" tire |
| 13P415_chart2.xls | 4/9/2012 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Add 6.2L SC |
| 13P415_chart.xls | 10/12/2011 | 12P415_5.0.6.2_4x2.1/4x4.RDMVer43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | P 265 70R 17 | 5500 | 21.2 | 16.06 | 41.38 | 0.4012 | 0.03899 |
| | | | | | 6000 | 21.8 | 17.05 | 44.91 | 0.4131 | 0.03907 |
| | | | | | 6500 | 22.3 | 17.99 | 48.44 | 0.4251 | 0.03916 |
| | | | | | 7000 | 22.9 | 18.88 | 51.98 | 0.4371 | 0.03925 |
| | | | | | 7500 | 23.5 | 19.73 | 55.53 | 0.4491 | 0.03933 |
| | | | | LT 245 75R 17 | 5500 | 21.7 | 15.64 | 47.76 | 0.3731 | 0.03867 |
| | | | | | 6000 | 22.3 | 16.61 | 51.64 | 0.3816 | 0.03872 |
| | | | | | 6500 | 22.9 | 17.53 | 55.51 | 0.3902 | 0.03877 |
| | | | | | 7000 | 23.5 | 18.40 | 59.36 | 0.3986 | 0.03883 |
| | | | | | 7500 | 24.1 | 19.23 | 63.20 | 0.4071 | 0.03888 |
| | | | | P 275 65R 18 | 5500 | 20.4 | 16.72 | 37.76 | 0.3672 | 0.03864 |
| | | | | | 6000 | 20.9 | 17.75 | 41.29 | 0.3775 | 0.03869 |
| | | | | | 6500 | 21.5 | 18.72 | 44.85 | 0.3879 | 0.03875 |
| | | | | | 7000 | 22.1 | 19.63 | 48.45 | 0.3985 | 0.03881 |
| | | | | | 7500 | 22.6 | 20.50 | 52.07 | 0.4091 | 0.03887 |
| | | | | LT 275 65R 18 | 5500 | 23.3 | 14.61 | 57.23 | 0.3727 | 0.03947 |
| | | | | | 6000 | 24.0 | 15.45 | 61.92 | 0.3819 | 0.03959 |
| | | | | | 6500 | 24.7 | 16.25 | 66.60 | 0.3910 | 0.03971 |
| | | | | | 7000 | 25.4 | 17.00 | 71.25 | 0.4002 | 0.03983 |
| | | | | | 7500 | 26.2 | 17.71 | 75.89 | 0.4092 | 0.03995 |
| | | | | P 275 55R 20 OWL & Bridgestone BSW | 5500 | 21.3 | 15.99 | 46.21 | 0.3366 | 0.03863 |
| | | | | | 6000 | 21.9 | 16.95 | 50.34 | 0.3431 | 0.03869 |
| | | | | | 6500 | 22.5 | 17.85 | 54.50 | 0.3496 | 0.03874 |
| | | | | | 7000 | 23.1 | 18.71 | 58.67 | 0.3561 | 0.03880 |
| | | | | | 7500 | 23.7 | 19.52 | 62.85 | 0.3626 | 0.03885 |
| | | | | P 275 55R 20 AT | 5500 | 23.2 | 14.68 | 58.24 | 0.3769 | 0.03864 |
| | | | | | 6000 | 23.9 | 15.49 | 63.44 | 0.3871 | 0.03869 |
| | | | | | 6500 | 24.7 | 16.25 | 68.65 | 0.3973 | 0.03874 |
| | | | | | 7000 | 25.5 | 16.96 | 73.87 | 0.4075 | 0.03880 |
| | | | | | 7500 | 26.3 | 17.63 | 79.10 | 0.4178 | 0.03885 |
| | | | | P 275 55R 20 BSW | 5500 | 21.6 | 15.72 | 46.83 | 0.3867 | 0.03844 |
| | | | | | 6000 | 22.3 | 16.62 | 51.26 | 0.3987 | 0.03848 |
| | | | | | 6500 | 23.0 | 17.46 | 55.73 | 0.4108 | 0.03852 |
| | | | | | 7000 | 23.7 | 18.25 | 60.24 | 0.4231 | 0.03855 |
| | | | | | 7500 | 24.4 | 18.99 | 64.78 | 0.4354 | 0.03859 |
| | | | | P 275 45R 22 | 5500 | 22.9 | 14.82 | 53.33 | 0.4589 | 0.03833 |
| | | | | | 6000 | 23.6 | 15.73 | 57.32 | 0.4740 | 0.03835 |
| | | | | | 6500 | 24.2 | 16.59 | 61.26 | 0.4889 | 0.03837 |
| | | | | | 7000 | 24.8 | 17.41 | 65.17 | 0.5036 | 0.03839 |
| | | | | | 7500 | 25.5 | 18.20 | 69.04 | 0.5182 | 0.03840 |
| | | | | P 255 65R 17 | 5500 | 21.2 | 16.02 | 40.99 | 0.4219 | 0.03888 |
| | | | | | 6000 | 21.8 | 17.03 | 44.42 | 0.4335 | 0.03896 |
| | | | | | 6500 | 22.4 | 17.98 | 47.86 | 0.4452 | 0.03904 |
| | | | | | 7000 | 22.9 | 18.88 | 51.30 | 0.4569 | 0.03913 |
| | | | | | 7500 | 23.5 | 19.74 | 54.74 | 0.4685 | 0.03921 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 F150 Raptor*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13P415_chart.xls | 10/12/2011 | 12Raptor_4x4.RDMver43.xls | 43 | Carryover 2012 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| F150 Raptor | 6.2L | All | 4x4 | LT 315 70R 17 | 6000 | 25.5 | 14.54 | 44.69 | 0.6198 | 0.04633 |
| | | | | | 6500 | 26.2 | 15.32 | 48.80 | 0.6430 | 0.04637 |
| | | | | | 7000 | 27.0 | 16.06 | 52.91 | 0.6662 | 0.04641 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| All F250/F350 SRW | 6.2L | Auto | 4x2 | LT 245 75R 17 AS | 6000 | 23.4 | 15.85 | 31.82 | 0.8687 | 0.04022 |
| 40.5 sq. ft. | | | | | 6500 | 23.9 | 16.80 | 35.04 | 0.8791 | 0.04023 |
| | | | | | 7000 | 24.4 | 17.72 | 38.24 | 0.8894 | 0.04024 |
| | | | | | 7500 | 24.9 | 18.61 | 41.42 | 0.8997 | 0.04025 |
| | | | | | 8000 | 25.4 | 19.46 | 44.57 | 0.9099 | 0.04026 |
| | | | | | 8500 | 25.9 | 20.29 | 47.71 | 0.9200 | 0.04027 |
| | | | | | 9000 | 26.4 | 21.08 | 50.83 | 0.9300 | 0.04028 |
| | | | | | 9500 | 26.9 | 21.85 | 53.93 | 0.9400 | 0.04029 |
| | | | | | 10000 | 27.4 | 22.59 | 57.02 | 0.9500 | 0.04031 |
| | | | | | 10500 | 27.9 | 23.31 | 60.09 | 0.9599 | 0.04032 |
| | | | | | 11000 | 28.3 | 24.00 | 63.15 | 0.9697 | 0.04033 |
| | | | | | 11500 | 28.8 | 24.68 | 66.19 | 0.9795 | 0.04034 |
| | | | | LT 245 75R 17 AT | 6000 | 23.9 | 15.54 | 34.79 | 0.8781 | 0.04023 |
| | | | | | 6500 | 24.4 | 16.46 | 38.25 | 0.8892 | 0.04024 |
| | | | | | 7000 | 25.0 | 17.34 | 41.67 | 0.9003 | 0.04025 |
| | | | | | 7500 | 25.5 | 18.19 | 45.08 | 0.9112 | 0.04026 |
| | | | | | 8000 | 26.0 | 19.01 | 48.46 | 0.9221 | 0.04027 |
| | | | | | 8500 | 26.6 | 19.79 | 51.82 | 0.9329 | 0.04029 |
| | | | | | 9000 | 27.1 | 20.55 | 55.16 | 0.9436 | 0.04030 |
| | | | | | 9500 | 27.6 | 21.28 | 58.48 | 0.9543 | 0.04031 |
| | | | | | 10000 | 28.1 | 21.99 | 61.79 | 0.9650 | 0.04032 |
| | | | | | 10500 | 28.6 | 22.67 | 65.08 | 0.9756 | 0.04033 |
| | | | | | 11000 | 29.1 | 23.33 | 68.36 | 0.9861 | 0.04035 |
| | | | | | 11500 | 29.6 | 23.97 | 71.62 | 0.9966 | 0.04036 |
| | | | | LT 265 70R 17 AT | 6000 | 23.9 | 15.53 | 36.45 | 0.8177 | 0.04082 |
| | | | | | 6500 | 24.5 | 16.43 | 40.12 | 0.8246 | 0.04088 |
| | | | | | 7000 | 25.0 | 17.31 | 43.76 | 0.8316 | 0.04094 |
| | | | | | 7500 | 25.6 | 18.14 | 47.39 | 0.8384 | 0.04100 |
| | | | | | 8000 | 26.1 | 18.94 | 50.99 | 0.8453 | 0.04106 |
| | | | | | 8500 | 26.7 | 19.71 | 54.58 | 0.8521 | 0.04112 |
| | | | | | 9000 | 27.2 | 20.45 | 58.16 | 0.8589 | 0.04118 |
| | | | | | 9500 | 27.7 | 21.17 | 61.71 | 0.8656 | 0.04124 |
| | | | | | 10000 | 28.3 | 21.85 | 65.26 | 0.8724 | 0.04130 |
| | | | | | 10500 | 28.8 | 22.52 | 68.79 | 0.8791 | 0.04136 |
| | | | | | 11000 | 29.4 | 23.16 | 72.30 | 0.8857 | 0.04142 |
| | | | | | 11500 | 29.9 | 23.78 | 75.81 | 0.8924 | 0.04147 |
| | | | | LT 275 65R 18 AS | 6000 | 24.3 | 15.30 | 41.83 | 0.7570 | 0.04094 |
| | | | | | 6500 | 24.8 | 16.18 | 45.82 | 0.7603 | 0.04101 |
| | | | | | 7000 | 25.4 | 17.03 | 49.79 | 0.7635 | 0.04108 |
| | | | | | 7500 | 26.0 | 17.84 | 53.72 | 0.7667 | 0.04115 |
| | | | | | 8000 | 26.6 | 18.62 | 57.64 | 0.7699 | 0.04122 |
| | | | | | 8500 | 27.1 | 19.38 | 61.52 | 0.7730 | 0.04129 |
| | | | | | 9000 | 27.7 | 20.10 | 65.39 | 0.7762 | 0.04136 |
| | | | | | 9500 | 28.2 | 20.79 | 69.24 | 0.7793 | 0.04143 |
| | | | | | 10000 | 28.8 | 21.46 | 73.06 | 0.7824 | 0.04150 |
| | | | | | 10500 | 29.3 | 22.11 | 76.87 | 0.7855 | 0.04157 |
| | | | | | 11000 | 29.9 | 22.74 | 80.66 | 0.7886 | 0.04163 |
| | | | | | 11500 | 30.4 | 23.34 | 84.43 | 0.7916 | 0.04170 |
| F250 CC SRW Only | 6.7L Diesel | Auto | 4x2 | LT 245 75R 17 AS | 6000 | 23.0 | 16.16 | 32.80 | 0.8687 | 0.03844 |
| 40.5 sq. ft. | | | | | 6500 | 23.5 | 17.13 | 36.02 | 0.8791 | 0.03845 |
| | | | | | 7000 | 24.0 | 18.06 | 39.22 | 0.8894 | 0.03846 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 7500 | 24.5 | 18.95 | 42.40 | 0.8997 | 0.03848 |
| | | | | | 8000 | 25.0 | 19.82 | 45.56 | 0.9099 | 0.03849 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 8500 | 25.5 | 20.65 | 48.70 | 0.9200 | 0.03850 |
| | | | | | 9000 | 25.9 | 21.45 | 51.82 | 0.9300 | 0.03851 |
| | | | | | 9500 | 26.4 | 22.22 | 54.92 | 0.9400 | 0.03852 |
| | | | | | 10000 | 26.9 | 22.97 | 58.01 | 0.9500 | 0.03853 |
| | | | | | 10500 | 27.4 | 23.70 | 61.08 | 0.9599 | 0.03854 |
| | | | | | 11000 | 27.9 | 24.40 | 64.14 | 0.9697 | 0.03855 |
| | | | | | 11500 | 28.3 | 25.08 | 67.18 | 0.9795 | 0.03856 |
| | | | | LT 245 75R 17 AT | 6000 | 23.4 | 15.84 | 35.78 | 0.8781 | 0.03845 |
| | | | | | 6500 | 24.0 | 16.77 | 39.23 | 0.8892 | 0.03846 |
| | | | | | 7000 | 24.5 | 17.66 | 42.66 | 0.9003 | 0.03848 |
| | | | | | 7500 | 25.0 | 18.52 | 46.06 | 0.9112 | 0.03849 |
| | | | | | 8000 | 25.6 | 19.35 | 49.45 | 0.9221 | 0.03850 |
| | | | | | 8500 | 26.1 | 20.14 | 52.81 | 0.9329 | 0.03851 |
| | | | | | 9000 | 26.6 | 20.90 | 56.15 | 0.9436 | 0.03852 |
| | | | | | 9500 | 27.1 | 21.64 | 59.47 | 0.9543 | 0.03854 |
| | | | | | 10000 | 27.7 | 22.35 | 62.78 | 0.9650 | 0.03855 |
| | | | | | 10500 | 28.2 | 23.04 | 66.07 | 0.9756 | 0.03856 |
| | | | | | 11000 | 28.7 | 23.71 | 69.34 | 0.9861 | 0.03857 |
| | | | | | 11500 | 29.2 | 24.35 | 72.60 | 0.9966 | 0.03858 |
| | | | | LT 265 70R 17 AT | 6000 | 23.5 | 15.83 | 37.43 | 0.8177 | 0.03905 |
| | | | | | 6500 | 24.0 | 16.75 | 41.10 | 0.8246 | 0.03911 |
| | | | | | 7000 | 24.6 | 17.63 | 44.74 | 0.8316 | 0.03917 |
| | | | | | 7500 | 25.1 | 18.47 | 48.37 | 0.8384 | 0.03923 |
| | | | | | 8000 | 25.7 | 19.28 | 51.98 | 0.8453 | 0.03929 |
| | | | | | 8500 | 26.2 | 20.06 | 55.56 | 0.8521 | 0.03935 |
| | | | | | 9000 | 26.7 | 20.80 | 59.14 | 0.8589 | 0.03941 |
| | | | | | 9500 | 27.3 | 21.52 | 62.70 | 0.8656 | 0.03947 |
| | | | | | 10000 | 27.8 | 22.21 | 66.24 | 0.8724 | 0.03953 |
| | | | | | 10500 | 28.4 | 22.88 | 69.77 | 0.8791 | 0.03958 |
| | | | | | 11000 | 28.9 | 23.53 | 73.29 | 0.8857 | 0.03964 |
| | | | | | 11500 | 29.4 | 24.15 | 76.79 | 0.8924 | 0.03970 |
| | | | | LT 275 65R 18 AS | 6000 | 23.8 | 15.59 | 42.79 | 0.7570 | 0.03916 |
| | | | | | 6500 | 24.4 | 16.49 | 46.79 | 0.7603 | 0.03924 |
| | | | | | 7000 | 25.0 | 17.34 | 50.75 | 0.7635 | 0.03931 |
| | | | | | 7500 | 25.5 | 18.16 | 54.69 | 0.7667 | 0.03938 |
| | | | | | 8000 | 26.1 | 18.95 | 58.60 | 0.7699 | 0.03945 |
| | | | | | 8500 | 26.7 | 19.71 | 62.49 | 0.7730 | 0.03952 |
| | | | | | 9000 | 27.2 | 20.44 | 66.36 | 0.7762 | 0.03959 |
| | | | | | 9500 | 27.8 | 21.14 | 70.20 | 0.7793 | 0.03966 |
| | | | | | 10000 | 28.3 | 21.81 | 74.03 | 0.7824 | 0.03972 |
| | | | | | 10500 | 28.9 | 22.46 | 77.83 | 0.7855 | 0.03979 |
| | | | | | 11000 | 29.4 | 23.09 | 81.62 | 0.7886 | 0.03986 |
| | | | | | 11500 | 30.0 | 23.70 | 85.40 | 0.7916 | 0.03993 |
| All F250/F350 SRW exc CC 40.5 sq. ft. | 6.7L Diesel | Auto | 4x2 | LT 245 75R 17 AS | 6000 | 23.4 | 15.87 | 32.80 | 0.8687 | 0.03972 |
| | | | | | 6500 | 23.9 | 16.83 | 36.02 | 0.8791 | 0.03973 |
| | | | | | 7000 | 24.4 | 17.75 | 39.22 | 0.8894 | 0.03975 |
| | | | | | 7500 | 24.9 | 18.63 | 42.40 | 0.8997 | 0.03976 |
| | | | | | 8000 | 25.4 | 19.48 | 45.56 | 0.9099 | 0.03977 |
| | | | | | 8500 | 25.9 | 20.31 | 48.70 | 0.9200 | 0.03978 |
| | | | | | 9000 | 26.4 | 21.10 | 51.82 | 0.9300 | 0.03979 |
| | | | | | 9500 | 26.9 | 21.87 | 54.92 | 0.9400 | 0.03980 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 10000 | 27.3 | 22.62 | 58.01 | 0.9500 | 0.03981 |
| | | | | | 10500 | 27.8 | 23.34 | 61.08 | 0.9599 | 0.03982 |
| | | | | | 11000 | 28.3 | 24.03 | 64.14 | 0.9697 | 0.03983 |
| | | | | | 11500 | 28.8 | 24.71 | 67.18 | 0.9795 | 0.03985 |



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ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | LT 245 75R 17 AT | 6000 | 23.9 | 15.56 | 35.78 | 0.8781 | 0.03973 |
| | | | | | 6500 | 24.4 | 16.48 | 39.23 | 0.8892 | 0.03975 |
| | | | | | 7000 | 24.9 | 17.36 | 42.66 | 0.9003 | 0.03976 |
| | | | | | 7500 | 25.5 | 18.21 | 46.06 | 0.9112 | 0.03977 |
| | | | | | 8000 | 26.0 | 19.03 | 49.45 | 0.9221 | 0.03978 |
| | | | | | 8500 | 26.5 | 19.82 | 52.81 | 0.9329 | 0.03979 |
| | | | | | 9000 | 27.0 | 20.57 | 56.15 | 0.9436 | 0.03981 |
| | | | | | 9500 | 27.6 | 21.31 | 59.47 | 0.9543 | 0.03982 |
| | | | | | 10000 | 28.1 | 22.01 | 62.78 | 0.9650 | 0.03983 |
| | | | | | 10500 | 28.6 | 22.70 | 66.07 | 0.9756 | 0.03984 |
| | | | | | 11000 | 29.1 | 23.36 | 69.34 | 0.9861 | 0.03985 |
| | | | | | 11500 | 29.6 | 24.00 | 72.60 | 0.9966 | 0.03986 |
| | | | | LT 265 70R 17 AT | 6000 | 23.9 | 15.55 | 37.43 | 0.8177 | 0.04033 |
| | | | | | 6500 | 24.4 | 16.46 | 41.10 | 0.8246 | 0.04039 |
| | | | | | 7000 | 25.0 | 17.33 | 44.74 | 0.8316 | 0.04045 |
| | | | | | 7500 | 25.5 | 18.16 | 48.37 | 0.8384 | 0.04051 |
| | | | | | 8000 | 26.1 | 18.96 | 51.98 | 0.8453 | 0.04057 |
| | | | | | 8500 | 26.6 | 19.74 | 55.56 | 0.8521 | 0.04063 |
| | | | | | 9000 | 27.2 | 20.48 | 59.14 | 0.8589 | 0.04069 |
| | | | | | 9500 | 27.7 | 21.19 | 62.70 | 0.8656 | 0.04075 |
| | | | | | 10000 | 28.3 | 21.88 | 66.24 | 0.8724 | 0.04081 |
| | | | | | 10500 | 28.8 | 22.54 | 69.77 | 0.8791 | 0.04087 |
| | | | | | 11000 | 29.3 | 23.19 | 73.29 | 0.8857 | 0.04092 |
| | | | | | 11500 | 29.8 | 23.81 | 76.79 | 0.8924 | 0.04098 |
| | | | | LT 275 65R 18 AS | 6000 | 24.2 | 15.32 | 42.79 | 0.7570 | 0.04045 |
| | | | | | 6500 | 24.8 | 16.20 | 46.79 | 0.7603 | 0.04052 |
| | | | | | 7000 | 25.4 | 17.05 | 50.75 | 0.7635 | 0.04059 |
| | | | | | 7500 | 26.0 | 17.87 | 54.69 | 0.7667 | 0.04066 |
| | | | | | 8000 | 26.5 | 18.65 | 58.60 | 0.7699 | 0.04073 |
| | | | | | 8500 | 27.1 | 19.40 | 62.49 | 0.7730 | 0.04080 |
| | | | | | 9000 | 27.6 | 20.12 | 66.36 | 0.7762 | 0.04087 |
| | | | | | 9500 | 28.2 | 20.82 | 70.20 | 0.7793 | 0.04094 |
| | | | | | 10000 | 28.8 | 21.49 | 74.03 | 0.7824 | 0.04101 |
| | | | | | 10500 | 29.3 | 22.14 | 77.83 | 0.7855 | 0.04107 |
| | | | | | 11000 | 29.9 | 22.76 | 81.62 | 0.7886 | 0.04114 |
| | | | | | 11500 | 30.4 | 23.37 | 85.40 | 0.7916 | 0.04121 |
| All F250/F350 SRW exc CC 51 sq.ft. | 6.7L Diesel | Auto | 4x2 | LT 245 75R 17 AS | 6000 | 26.9 | 13.79 | 32.80 | 0.8687 | 0.05033 |
| | | | | | 6500 | 27.4 | 14.66 | 36.02 | 0.8791 | 0.05035 |
| | | | | | 7000 | 27.9 | 15.51 | 39.22 | 0.8894 | 0.05036 |
| | | | | | 7500 | 28.4 | 16.32 | 42.40 | 0.8997 | 0.05037 |
| | | | | | 8000 | 28.9 | 17.11 | 45.56 | 0.9099 | 0.05038 |
| | | | | | 8500 | 29.4 | 17.88 | 48.70 | 0.9200 | 0.05039 |
| | | | | | 9000 | 29.9 | 18.62 | 51.82 | 0.9300 | 0.05040 |
| | | | | | 9500 | 30.4 | 19.34 | 54.92 | 0.9400 | 0.05041 |
| | | | | | 10000 | 30.9 | 20.04 | 58.01 | 0.9500 | 0.05042 |
| | | | | | 10500 | 31.4 | 20.71 | 61.08 | 0.9599 | 0.05044 |
| | | | | | 11000 | 31.8 | 21.37 | 64.14 | 0.9697 | 0.05045 |
| | | | | | 11500 | 32.3 | 22.01 | 67.18 | 0.9795 | 0.05046 |
| | | | | LT 245 75R 17 AT | 6000 | 27.4 | 13.56 | 35.78 | 0.8781 | 0.05034 |
| | | | | | 6500 | 27.9 | 14.40 | 39.23 | 0.8892 | 0.05036 |
| | | | | | 7000 | 28.5 | 15.21 | 42.66 | 0.9003 | 0.05037 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 7500 | 29.0 | 16.00 | 46.06 | 0.9112 | 0.05038 |
| | | | | | 8000 | 29.5 | 16.76 | 49.45 | 0.9221 | 0.05039 |
| | | | | | 8500 | 30.1 | 17.49 | 52.81 | 0.9329 | 0.05041 |
| | | | | | 9000 | 30.6 | 18.20 | 56.15 | 0.9436 | 0.05042 |
| | | | | | 9500 | 31.1 | 18.89 | 59.47 | 0.9543 | 0.05043 |
| | | | | | 10000 | 31.6 | 19.56 | 62.78 | 0.9650 | 0.05044 |
| | | | | | 10500 | 32.1 | 20.21 | 66.07 | 0.9756 | 0.05045 |
| | | | | | 11000 | 32.6 | 20.84 | 69.34 | 0.9861 | 0.05046 |
| | | | | | 11500 | 33.2 | 21.45 | 72.60 | 0.9966 | 0.05048 |
| | | | | LT 265 70R 17 AT | 6000 | 27.4 | 13.55 | 37.43 | 0.8177 | 0.05094 |
| | | | | | 6500 | 28.0 | 14.38 | 41.10 | 0.8246 | 0.05100 |
| | | | | | 7000 | 28.5 | 15.19 | 44.74 | 0.8316 | 0.05106 |
| | | | | | 7500 | 29.1 | 15.96 | 48.37 | 0.8384 | 0.05112 |
| | | | | | 8000 | 29.6 | 16.71 | 51.98 | 0.8453 | 0.05118 |
| | | | | | 8500 | 30.2 | 17.43 | 55.56 | 0.8521 | 0.05124 |
| | | | | | 9000 | 30.7 | 18.13 | 59.14 | 0.8589 | 0.05130 |
| | | | | | 9500 | 31.3 | 18.80 | 62.70 | 0.8656 | 0.05136 |
| | | | | | 10000 | 31.8 | 19.45 | 66.24 | 0.8724 | 0.05142 |
| | | | | | 10500 | 32.3 | 20.09 | 69.77 | 0.8791 | 0.05148 |
| | | | | | 11000 | 32.9 | 20.70 | 73.29 | 0.8857 | 0.05154 |
| | | | | | 11500 | 33.4 | 21.30 | 76.79 | 0.8924 | 0.05159 |
| | | | | LT 275 65R 18 AS | 6000 | 27.8 | 13.37 | 42.79 | 0.7570 | 0.05106 |
| | | | | | 6500 | 28.4 | 14.19 | 46.79 | 0.7603 | 0.05113 |
| | | | | | 7000 | 28.9 | 14.98 | 50.75 | 0.7635 | 0.05120 |
| | | | | | 7500 | 29.5 | 15.73 | 54.69 | 0.7667 | 0.05127 |
| | | | | | 8000 | 30.1 | 16.46 | 58.60 | 0.7699 | 0.05134 |
| | | | | | 8500 | 30.6 | 17.17 | 62.49 | 0.7730 | 0.05141 |
| | | | | | 9000 | 31.2 | 17.85 | 66.36 | 0.7762 | 0.05148 |
| | | | | | 9500 | 31.7 | 18.51 | 70.20 | 0.7793 | 0.05155 |
| | | | | | 10000 | 32.3 | 19.15 | 74.03 | 0.7824 | 0.05162 |
| | | | | | 10500 | 32.8 | 19.76 | 77.83 | 0.7855 | 0.05169 |
| | | | | | 11000 | 33.4 | 20.36 | 81.62 | 0.7886 | 0.05175 |
| | | | | | 11500 | 33.9 | 20.94 | 85.40 | 0.7916 | 0.05182 |
| All F350 DRW | 6.2L | Auto | 4x2 | LT 245 75R 17 AS | 6000 | 24.7 | 15.02 | 33.91 | 0.8723 | 0.04318 |
| 40.5 sq. ft. | | | | | 6500 | 25.2 | 15.94 | 37.22 | 0.8830 | 0.04319 |
| | | | | | 7000 | 25.8 | 16.82 | 40.50 | 0.8936 | 0.04320 |
| | | | | | 7500 | 26.3 | 17.67 | 43.77 | 0.9041 | 0.04321 |
| | | | | | 8000 | 26.8 | 18.49 | 47.01 | 0.9145 | 0.04322 |
| | | | | | 8500 | 27.3 | 19.28 | 50.23 | 0.9249 | 0.04323 |
| | | | | | 9000 | 27.8 | 20.04 | 53.43 | 0.9352 | 0.04325 |
| | | | | | 9500 | 28.3 | 20.78 | 56.61 | 0.9455 | 0.04326 |
| | | | | | 10000 | 28.8 | 21.50 | 59.78 | 0.9557 | 0.04327 |
| | | | | | 10500 | 29.3 | 22.19 | 62.94 | 0.9658 | 0.04328 |
| | | | | | 11000 | 29.7 | 22.86 | 66.08 | 0.9760 | 0.04329 |
| | | | | | 11500 | 30.2 | 23.51 | 69.20 | 0.9860 | 0.04330 |
| All F350 DRW | 6.7L Diesel | Auto | 4x2 | LT 245 75R 17 AS | 6000 | 25.0 | 14.84 | 34.90 | 0.8723 | 0.04367 |
| 40.5 sq. ft. | | | | | 6500 | 25.5 | 15.75 | 38.21 | 0.8830 | 0.04368 |
| | | | | | 7000 | 26.1 | 16.63 | 41.49 | 0.8936 | 0.04369 |
| | | | | | 7500 | 26.6 | 17.47 | 44.75 | 0.9041 | 0.04370 |
| | | | | | 8000 | 27.1 | 18.28 | 47.99 | 0.9145 | 0.04372 |
| | | | | | 8500 | 27.6 | 19.07 | 51.21 | 0.9249 | 0.04373 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 9000 | 28.1 | 19.83 | 54.42 | 0.9352 | 0.04374 |
| | | | | | 9500 | 28.6 | 20.57 | 57.60 | 0.9455 | 0.04375 |
| | | | | | 10000 | 29.1 | 21.28 | 60.77 | 0.9557 | 0.04376 |
| | | | | | 10500 | 29.6 | 21.97 | 63.92 | 0.9658 | 0.04377 |
| | | | | | 11000 | 30.0 | 22.64 | 67.06 | 0.9760 | 0.04378 |
| | | | | | 11500 | 30.5 | 23.28 | 70.19 | 0.9860 | 0.04380 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| All F350 DRW | 6.7L Diesel | Auto | 4x2 | LT 245 75R 17 AS | 7500 | 30.4 | 15.25 | 44.75 | 0.9041 | 0.05534 |
| 51 sq.ft. | | | | | 8000 | 30.9 | 16.00 | 47.99 | 0.9145 | 0.05535 |
| | | | | | 8500 | 31.4 | 16.73 | 51.21 | 0.9249 | 0.05536 |
| | | | | | 9000 | 32.0 | 17.43 | 54.42 | 0.9352 | 0.05538 |
| | | | | | 9500 | 32.4 | 18.12 | 57.60 | 0.9455 | 0.05539 |
| | | | | | 10000 | 32.9 | 18.78 | 60.77 | 0.9557 | 0.05540 |
| | | | | | 10500 | 33.4 | 19.43 | 63.92 | 0.9658 | 0.05541 |
| | | | | | 11000 | 33.9 | 20.06 | 67.06 | 0.9760 | 0.05542 |
| | | | | | 11500 | 34.4 | 20.67 | 70.19 | 0.9860 | 0.05543 |
| | | | | | 12000 | 34.9 | 21.27 | 73.30 | 0.9960 | 0.05544 |
| | | | | | 12500 | 35.4 | 21.85 | 76.40 | 1.0060 | 0.05545 |
| | | | | | 13000 | 35.9 | 22.41 | 79.48 | 1.0160 | 0.05547 |
| All F250/F350 SRW | 6.2L | Auto | 4x4 | LT 245 75R 17 AS | 6500 | 26.0 | 15.46 | 23.75 | 1.7783 | 0.03299 |
| 40.5 sq. ft. | | | | | 7000 | 26.5 | 16.34 | 26.88 | 1.7884 | 0.03300 |
| | | | | | 7500 | 27.0 | 17.19 | 29.98 | 1.7984 | 0.03301 |
| | | | | | 8000 | 27.5 | 18.01 | 33.07 | 1.8084 | 0.03302 |
| | | | | | 8500 | 28.0 | 18.81 | 36.14 | 1.8183 | 0.03303 |
| | | | | | 9000 | 28.4 | 19.58 | 39.19 | 1.8281 | 0.03304 |
| | | | | | 9500 | 28.9 | 20.33 | 42.22 | 1.8379 | 0.03305 |
| | | | | | 10000 | 29.4 | 21.05 | 45.24 | 1.8476 | 0.03306 |
| | | | | | 10500 | 29.8 | 21.76 | 48.25 | 1.8573 | 0.03307 |
| | | | | | 11000 | 30.3 | 22.44 | 51.24 | 1.8669 | 0.03309 |
| | | | | | 11500 | 30.8 | 23.10 | 54.21 | 1.8765 | 0.03310 |
| | | | | | 12000 | 31.2 | 23.75 | 57.18 | 1.8860 | 0.03311 |
| | | | | LT 245 75R 17 AT | 6500 | 26.5 | 15.17 | 26.88 | 1.7882 | 0.03300 |
| | | | | | 7000 | 27.0 | 16.02 | 30.24 | 1.7990 | 0.03301 |
| | | | | | 7500 | 27.5 | 16.84 | 33.56 | 1.8097 | 0.03302 |
| | | | | | 8000 | 28.1 | 17.63 | 36.87 | 1.8203 | 0.03303 |
| | | | | | 8500 | 28.6 | 18.39 | 40.16 | 1.8309 | 0.03305 |
| | | | | | 9000 | 29.1 | 19.13 | 43.42 | 1.8414 | 0.03306 |
| | | | | | 9500 | 29.6 | 19.85 | 46.67 | 1.8519 | 0.03307 |
| | | | | | 10000 | 30.1 | 20.54 | 49.91 | 1.8623 | 0.03308 |
| | | | | | 10500 | 30.6 | 21.21 | 53.13 | 1.8726 | 0.03309 |
| | | | | | 11000 | 31.1 | 21.86 | 56.33 | 1.8829 | 0.03310 |
| | | | | | 11500 | 31.6 | 22.50 | 59.52 | 1.8932 | 0.03311 |
| | | | | | 12000 | 32.1 | 23.11 | 62.69 | 1.9034 | 0.03313 |
| | | | | LT 265 70R 17 AT | 6500 | 26.5 | 15.16 | 28.64 | 1.7158 | 0.03379 |
| | | | | | 7000 | 27.1 | 16.00 | 32.20 | 1.7225 | 0.03385 |
| | | | | | 7500 | 27.6 | 16.81 | 35.74 | 1.7292 | 0.03391 |
| | | | | | 8000 | 28.1 | 17.59 | 39.26 | 1.7359 | 0.03397 |
| | | | | | 8500 | 28.7 | 18.34 | 42.76 | 1.7426 | 0.03402 |
| | | | | | 9000 | 29.2 | 19.07 | 46.25 | 1.7492 | 0.03408 |
| | | | | | 9500 | 29.7 | 19.77 | 49.72 | 1.7558 | 0.03414 |
| | | | | | 10000 | 30.2 | 20.44 | 53.18 | 1.7623 | 0.03420 |
| | | | | | 10500 | 30.8 | 21.10 | 56.62 | 1.7689 | 0.03425 |
| | | | | | 11000 | 31.3 | 21.73 | 60.06 | 1.7754 | 0.03431 |
| | | | | | 11500 | 31.8 | 22.35 | 63.48 | 1.7819 | 0.03437 |
| | | | | | 12000 | 32.3 | 22.95 | 66.89 | 1.7884 | 0.03442 |
| | | | | LT 275 65R 18 AS | 6500 | 27.0 | 14.88 | 35.23 | 1.6237 | 0.03447 |
| | | | | | 7000 | 27.6 | 15.70 | 39.16 | 1.6269 | 0.03454 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 7500 | 28.1 | 16.48 | 43.07 | 1.6300 | 0.03461 |
| | | | | | 8000 | 28.7 | 17.23 | 46.95 | 1.6332 | 0.03468 |
| | | | | | 8500 | 29.3 | 17.96 | 50.81 | 1.6363 | 0.03474 |
| | | | | | 9000 | 29.8 | 18.66 | 54.65 | 1.6394 | 0.03481 |
| | | | | | 9500 | 30.4 | 19.33 | 58.46 | 1.6425 | 0.03488 |
| | | | | | 10000 | 30.9 | 19.99 | 62.26 | 1.6456 | 0.03495 |
| | | | | | 10500 | 31.5 | 20.62 | 66.03 | 1.6487 | 0.03502 |
| | | | | | 11000 | 32.0 | 21.23 | 69.79 | 1.6518 | 0.03508 |
| | | | | | 11500 | 32.6 | 21.83 | 73.53 | 1.6548 | 0.03515 |
| | | | | | 12000 | 33.1 | 22.40 | 77.26 | 1.6578 | 0.03522 |
| | | | | LT 275 70R 18 AT | 6500 | 27.9 | 14.39 | 37.86 | 1.6963 | 0.03475 |
| | | | | | 7000 | 28.6 | 15.14 | 41.97 | 1.7114 | 0.03476 |
| | | | | | 7500 | 29.2 | 15.86 | 46.06 | 1.7264 | 0.03478 |
| | | | | | 8000 | 29.9 | 16.55 | 50.12 | 1.7413 | 0.03480 |
| | | | | | 8500 | 30.5 | 17.21 | 54.16 | 1.7562 | 0.03481 |
| | | | | | 9000 | 31.2 | 17.85 | 58.17 | 1.7709 | 0.03483 |
| | | | | | 9500 | 31.8 | 18.46 | 62.17 | 1.7856 | 0.03485 |
| | | | | | 10000 | 32.4 | 19.05 | 66.14 | 1.8002 | 0.03486 |
| | | | | | 10500 | 33.1 | 19.62 | 70.09 | 1.8147 | 0.03488 |
| | | | | | 11000 | 33.7 | 20.17 | 74.03 | 1.8292 | 0.03490 |
| | | | | | 11500 | 34.3 | 20.70 | 77.95 | 1.8436 | 0.03491 |
| | | | | | 12000 | 34.9 | 21.21 | 81.85 | 1.8579 | 0.03493 |
| | | | | LT 275 65R 20 AT | 6500 | 27.5 | 14.59 | 38.55 | 1.5029 | 0.03717 |
| | | | | | 7000 | 28.2 | 15.34 | 42.85 | 1.5097 | 0.03731 |
| | | | | | 7500 | 28.9 | 16.06 | 47.13 | 1.5165 | 0.03745 |
| | | | | | 8000 | 29.5 | 16.75 | 51.39 | 1.5233 | 0.03759 |
| | | | | | 8500 | 30.2 | 17.40 | 55.63 | 1.5301 | 0.03773 |
| | | | | | 9000 | 30.9 | 18.03 | 59.86 | 1.5369 | 0.03787 |
| | | | | | 9500 | 31.5 | 18.64 | 64.07 | 1.5436 | 0.03800 |
| | | | | | 10000 | 32.2 | 19.22 | 68.27 | 1.5503 | 0.03814 |
| | | | | | 10500 | 32.8 | 19.78 | 72.45 | 1.5569 | 0.03827 |
| | | | | | 11000 | 33.4 | 20.32 | 76.63 | 1.5636 | 0.03841 |
| | | | | | 11500 | 34.1 | 20.84 | 80.78 | 1.5702 | 0.03854 |
| | | | | | 12000 | 34.7 | 21.35 | 84.93 | 1.5768 | 0.03868 |
| All F250/F350 SRW | 6.7L Diesel | Auto | 4x4 | LT 245 75R 17 AS | 6500 | 25.9 | 15.54 | 24.73 | 1.7783 | 0.03220 |
| 40.5 sq. ft. | | | | | 7000 | 26.4 | 16.42 | 27.86 | 1.7884 | 0.03221 |
| | | | | | 7500 | 26.9 | 17.27 | 30.97 | 1.7984 | 0.03222 |
| | | | | | 8000 | 27.3 | 18.10 | 34.06 | 1.8084 | 0.03223 |
| | | | | | 8500 | 27.8 | 18.90 | 37.12 | 1.8183 | 0.03224 |
| | | | | | 9000 | 28.3 | 19.67 | 40.17 | 1.8281 | 0.03225 |
| | | | | | 9500 | 28.8 | 20.42 | 43.21 | 1.8379 | 0.03226 |
| | | | | | 10000 | 29.2 | 21.14 | 46.23 | 1.8476 | 0.03228 |
| | | | | | 10500 | 29.7 | 21.85 | 49.23 | 1.8573 | 0.03229 |
| | | | | | 11000 | 30.2 | 22.53 | 52.22 | 1.8669 | 0.03230 |
| | | | | | 11500 | 30.6 | 23.20 | 55.20 | 1.8765 | 0.03231 |
| | | | | | 12000 | 31.1 | 23.85 | 58.16 | 1.8860 | 0.03232 |
| | | | | LT 245 75R 17 AT | 6500 | 26.4 | 15.25 | 27.87 | 1.7882 | 0.03221 |
| | | | | | 7000 | 26.9 | 16.10 | 31.22 | 1.7990 | 0.03222 |
| | | | | | 7500 | 27.4 | 16.92 | 34.55 | 1.8097 | 0.03223 |
| | | | | | 8000 | 27.9 | 17.71 | 37.86 | 1.8203 | 0.03225 |
| | | | | | 8500 | 28.4 | 18.48 | 41.14 | 1.8309 | 0.03226 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 9000 | 29.0 | 19.22 | 44.41 | 1.8414 | 0.03227 |
| | | | | | 9500 | 29.5 | 19.94 | 47.66 | 1.8519 | 0.03228 |
| | | | | | 10000 | 30.0 | 20.63 | 50.89 | 1.8623 | 0.03229 |
| | | | | | 10500 | 30.5 | 21.30 | 54.11 | 1.8726 | 0.03230 |
| | | | | | 11000 | 31.0 | 21.96 | 57.31 | 1.8829 | 0.03231 |
| | | | | | 11500 | 31.5 | 22.59 | 60.50 | 1.8932 | 0.03233 |
| | | | | | 12000 | 32.0 | 23.20 | 63.68 | 1.9034 | 0.03234 |

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | LT 265 70R 17 AT | 6500 | 26.4 | 15.24 | 29.63 | 1.7158 | 0.03300 |
| | | | | | 7000 | 26.9 | 16.08 | 33.18 | 1.7225 | 0.03306 |
| | | | | | 7500 | 27.5 | 16.89 | 36.72 | 1.7292 | 0.03312 |
| | | | | | 8000 | 28.0 | 17.67 | 40.24 | 1.7359 | 0.03318 |
| | | | | | 8500 | 28.5 | 18.42 | 43.74 | 1.7426 | 0.03324 |
| | | | | | 9000 | 29.1 | 19.15 | 47.23 | 1.7492 | 0.03329 |
| | | | | | 9500 | 29.6 | 19.85 | 50.70 | 1.7558 | 0.03335 |
| | | | | | 10000 | 30.1 | 20.53 | 54.16 | 1.7623 | 0.03341 |
| | | | | | 10500 | 30.6 | 21.19 | 57.61 | 1.7689 | 0.03347 |
| | | | | | 11000 | 31.1 | 21.83 | 61.04 | 1.7754 | 0.03352 |
| | | | | | 11500 | 31.7 | 22.44 | 64.46 | 1.7819 | 0.03358 |
| | | | | | 12000 | 32.2 | 23.04 | 67.87 | 1.7884 | 0.03364 |
| | | | | LT 275 65R 18 AS | 6500 | 26.9 | 14.96 | 36.20 | 1.6237 | 0.03368 |
| | | | | | 7000 | 27.4 | 15.77 | 40.13 | 1.6269 | 0.03375 |
| | | | | | 7500 | 28.0 | 16.56 | 44.04 | 1.6300 | 0.03382 |
| | | | | | 8000 | 28.6 | 17.31 | 47.92 | 1.6332 | 0.03389 |
| | | | | | 8500 | 29.1 | 18.04 | 51.78 | 1.6363 | 0.03396 |
| | | | | | 9000 | 29.7 | 18.74 | 55.61 | 1.6394 | 0.03402 |
| | | | | | 9500 | 30.2 | 19.42 | 59.43 | 1.6425 | 0.03409 |
| | | | | | 10000 | 30.8 | 20.07 | 63.22 | 1.6456 | 0.03416 |
| | | | | | 10500 | 31.3 | 20.71 | 67.00 | 1.6487 | 0.03423 |
| | | | | | 11000 | 31.9 | 21.32 | 70.76 | 1.6518 | 0.03430 |
| | | | | | 11500 | 32.4 | 21.92 | 74.50 | 1.6548 | 0.03436 |
| | | | | | 12000 | 33.0 | 22.49 | 78.23 | 1.6578 | 0.03443 |
| | | | | LT 275 70R 18 AT | 6500 | 27.8 | 14.46 | 38.79 | 1.6963 | 0.03396 |
| | | | | | 7000 | 28.5 | 15.21 | 42.91 | 1.7114 | 0.03397 |
| | | | | | 7500 | 29.1 | 15.93 | 47.00 | 1.7264 | 0.03399 |
| | | | | | 8000 | 29.8 | 16.62 | 51.06 | 1.7413 | 0.03401 |
| | | | | | 8500 | 30.4 | 17.28 | 55.10 | 1.7562 | 0.03403 |
| | | | | | 9000 | 31.0 | 17.92 | 59.11 | 1.7709 | 0.03404 |
| | | | | | 9500 | 31.7 | 18.54 | 63.10 | 1.7856 | 0.03406 |
| | | | | | 10000 | 32.3 | 19.13 | 67.08 | 1.8002 | 0.03408 |
| | | | | | 10500 | 32.9 | 19.70 | 71.03 | 1.8147 | 0.03409 |
| | | | | | 11000 | 33.6 | 20.25 | 74.96 | 1.8292 | 0.03411 |
| | | | | | 11500 | 34.2 | 20.78 | 78.88 | 1.8436 | 0.03413 |
| | | | | | 12000 | 34.8 | 21.30 | 82.79 | 1.8579 | 0.03414 |
| | | | | LT 275 65R 20 AT | 6500 | 27.4 | 14.67 | 39.46 | 1.5029 | 0.03639 |
| | | | | | 7000 | 28.1 | 15.42 | 43.76 | 1.5097 | 0.03653 |
| | | | | | 7500 | 28.7 | 16.14 | 48.04 | 1.5165 | 0.03666 |
| | | | | | 8000 | 29.4 | 16.83 | 52.30 | 1.5233 | 0.03680 |
| | | | | | 8500 | 30.1 | 17.48 | 56.54 | 1.5301 | 0.03694 |
| | | | | | 9000 | 30.7 | 18.11 | 60.77 | 1.5369 | 0.03708 |
| | | | | | 9500 | 31.4 | 18.72 | 64.98 | 1.5436 | 0.03721 |
| | | | | | 10000 | 32.0 | 19.31 | 69.18 | 1.5503 | 0.03735 |
| | | | | | 10500 | 32.7 | 19.87 | 73.37 | 1.5569 | 0.03749 |
| | | | | | 11000 | 33.3 | 20.41 | 77.54 | 1.5636 | 0.03762 |
| | | | | | 11500 | 33.9 | 20.93 | 81.70 | 1.5702 | 0.03776 |
| | | | | | 12000 | 34.6 | 21.43 | 85.84 | 1.5768 | 0.03789 |
| All F250/F350 SRW | 6.7L Diesel | Auto | 4x4 | LT 245 75R 17 AS | 6500 | 29.6 | 13.61 | 24.73 | 1.7783 | 0.04325 |
| 51 sq. ft. | | | | | 7000 | 30.1 | 14.42 | 27.86 | 1.7884 | 0.04326 |
| | | | | | 7500 | 30.5 | 15.20 | 30.97 | 1.7984 | 0.04327 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 8000 | 31.0 | 15.96 | 34.06 | 1.8084 | 0.04328 |
| | | | | | 8500 | 31.5 | 16.70 | 37.12 | 1.8183 | 0.04329 |
| | | | | | 9000 | 32.0 | 17.41 | 40.17 | 1.8281 | 0.04330 |
| | | | | | 9500 | 32.5 | 18.11 | 43.21 | 1.8379 | 0.04331 |
| | | | | | 10000 | 32.9 | 18.79 | 46.23 | 1.8476 | 0.04332 |
| | | | | | 10500 | 33.4 | 19.45 | 49.23 | 1.8573 | 0.04333 |
| | | | | | 11000 | 33.9 | 20.09 | 52.22 | 1.8669 | 0.04334 |
| | | | | | 11500 | 34.3 | 20.72 | 55.20 | 1.8765 | 0.04336 |
| | | | | | 12000 | 34.8 | 21.33 | 58.16 | 1.8860 | 0.04337 |
| | | | | LT 245 75R 17 AT | 6500 | 30.1 | 13.39 | 27.87 | 1.7882 | 0.04326 |
| | | | | | 7000 | 30.6 | 14.17 | 31.22 | 1.7990 | 0.04327 |
| | | | | | 7500 | 31.1 | 14.92 | 34.55 | 1.8097 | 0.04328 |
| | | | | | 8000 | 31.6 | 15.66 | 37.86 | 1.8203 | 0.04329 |
| | | | | | 8500 | 32.1 | 16.37 | 41.14 | 1.8309 | 0.04330 |
| | | | | | 9000 | 32.6 | 17.06 | 44.41 | 1.8414 | 0.04332 |
| | | | | | 9500 | 33.1 | 17.73 | 47.66 | 1.8519 | 0.04333 |
| | | | | | 10000 | 33.6 | 18.38 | 50.89 | 1.8623 | 0.04334 |
| | | | | | 10500 | 34.1 | 19.02 | 54.11 | 1.8726 | 0.04335 |
| | | | | | 11000 | 34.6 | 19.63 | 57.31 | 1.8829 | 0.04336 |
| | | | | | 11500 | 35.1 | 20.23 | 60.50 | 1.8932 | 0.04337 |
| | | | | | 12000 | 35.6 | 20.81 | 63.68 | 1.9034 | 0.04339 |
| | | | | LT 265 70R 17 AT | 6500 | 30.1 | 13.38 | 29.63 | 1.7158 | 0.04405 |
| | | | | | 7000 | 30.6 | 14.15 | 33.18 | 1.7225 | 0.04411 |
| | | | | | 7500 | 31.1 | 14.90 | 36.72 | 1.7292 | 0.04417 |
| | | | | | 8000 | 31.7 | 15.62 | 40.24 | 1.7359 | 0.04423 |
| | | | | | 8500 | 32.2 | 16.33 | 43.74 | 1.7426 | 0.04428 |
| | | | | | 9000 | 32.7 | 17.01 | 47.23 | 1.7492 | 0.04434 |
| | | | | | 9500 | 33.3 | 17.66 | 50.70 | 1.7558 | 0.04440 |
| | | | | | 10000 | 33.8 | 18.30 | 54.16 | 1.7623 | 0.04446 |
| | | | | | 10500 | 34.3 | 18.92 | 57.61 | 1.7689 | 0.04451 |
| | | | | | 11000 | 34.8 | 19.53 | 61.04 | 1.7754 | 0.04457 |
| | | | | | 11500 | 35.4 | 20.11 | 64.46 | 1.7819 | 0.04463 |
| | | | | | 12000 | 35.9 | 20.68 | 67.87 | 1.7884 | 0.04468 |
| | | | | LT 275 65R 18 AS | 6500 | 30.6 | 13.16 | 36.20 | 1.6237 | 0.04472 |
| | | | | | 7000 | 31.1 | 13.91 | 40.13 | 1.6269 | 0.04479 |
| | | | | | 7500 | 31.7 | 14.64 | 44.04 | 1.6300 | 0.04486 |
| | | | | | 8000 | 32.3 | 15.34 | 47.92 | 1.6332 | 0.04493 |
| | | | | | 8500 | 32.8 | 16.02 | 51.78 | 1.6363 | 0.04500 |
| | | | | | 9000 | 33.4 | 16.68 | 55.61 | 1.6394 | 0.04507 |
| | | | | | 9500 | 33.9 | 17.32 | 59.43 | 1.6425 | 0.04514 |
| | | | | | 10000 | 34.5 | 17.94 | 63.22 | 1.6456 | 0.04521 |
| | | | | | 10500 | 35.0 | 18.54 | 67.00 | 1.6487 | 0.04528 |
| | | | | | 11000 | 35.6 | 19.12 | 70.76 | 1.6518 | 0.04534 |
| | | | | | 11500 | 36.1 | 19.69 | 74.50 | 1.6548 | 0.04541 |
| | | | | | 12000 | 36.6 | 20.24 | 78.23 | 1.6578 | 0.04548 |
| | | | | LT 275 70R 18 AT | 6500 | 31.5 | 12.77 | 38.79 | 1.6963 | 0.04501 |
| | | | | | 7000 | 32.1 | 13.48 | 42.91 | 1.7114 | 0.04502 |
| | | | | | 7500 | 32.8 | 14.15 | 47.00 | 1.7264 | 0.04504 |
| | | | | | 8000 | 33.4 | 14.80 | 51.06 | 1.7413 | 0.04506 |
| | | | | | 8500 | 34.1 | 15.42 | 55.10 | 1.7562 | 0.04507 |
| | | | | | 9000 | 34.7 | 16.03 | 59.11 | 1.7709 | 0.04509 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Description | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 9500 | 35.4 | 16.61 | 63.10 | 1.7856 | 0.04511 |
| | | | | | 10000 | 36.0 | 17.18 | 67.08 | 1.8002 | 0.04512 |
| | | | | | 10500 | 36.6 | 17.73 | 71.03 | 1.8147 | 0.04514 |
| | | | | | 11000 | 37.2 | 18.26 | 74.96 | 1.8292 | 0.04516 |
| | | | | | 11500 | 37.9 | 18.77 | 78.88 | 1.8436 | 0.04517 |
| | | | | | 12000 | 38.5 | 19.27 | 82.79 | 1.8579 | 0.04519 |

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Description | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | LT 275 65R 20 AT | 6500 | 31.1 | 12.94 | 39.46 | 1.5029 | 0.04743 |
| | | | | | 7000 | 31.8 | 13.64 | 43.76 | 1.5097 | 0.04757 |
| | | | | | 7500 | 32.4 | 14.31 | 48.04 | 1.5165 | 0.04771 |
| | | | | | 8000 | 33.1 | 14.96 | 52.30 | 1.5233 | 0.04785 |
| | | | | | 8500 | 33.7 | 15.58 | 56.54 | 1.5301 | 0.04799 |
| | | | | | 9000 | 34.4 | 16.18 | 60.77 | 1.5369 | 0.04813 |
| | | | | | 9500 | 35.0 | 16.76 | 64.98 | 1.5436 | 0.04826 |
| | | | | | 10000 | 35.7 | 17.32 | 69.18 | 1.5503 | 0.04840 |
| | | | | | 10500 | 36.3 | 17.86 | 73.37 | 1.5569 | 0.04853 |
| | | | | | 11000 | 37.0 | 18.38 | 77.54 | 1.5636 | 0.04867 |
| | | | | | 11500 | 37.6 | 18.89 | 81.70 | 1.5702 | 0.04880 |
| | | | | | 12000 | 38.3 | 19.38 | 85.84 | 1.5768 | 0.04894 |
| All F350 DRW | 6.2L | Auto | 4x4 | LT 245 75R 17 AS | 6500 | 27.3 | 14.72 | 25.93 | 1.7822 | 0.03595 |
| 40.5 sq. ft. | | | | | 7000 | 27.8 | 15.57 | 29.14 | 1.7925 | 0.03596 |
| | | | | | 7500 | 28.3 | 16.39 | 32.33 | 1.8028 | 0.03597 |
| | | | | | 8000 | 28.8 | 17.18 | 35.50 | 1.8130 | 0.03598 |
| | | | | | 8500 | 29.3 | 17.94 | 38.65 | 1.8232 | 0.03599 |
| | | | | | 9000 | 29.8 | 18.68 | 41.79 | 1.8333 | 0.03600 |
| | | | | | 9500 | 30.3 | 19.40 | 44.90 | 1.8433 | 0.03602 |
| | | | | | 10000 | 30.8 | 20.10 | 48.00 | 1.8533 | 0.03603 |
| | | | | | 10500 | 31.2 | 20.78 | 51.09 | 1.8633 | 0.03604 |
| | | | | | 11000 | 31.7 | 21.44 | 54.16 | 1.8732 | 0.03605 |
| | | | | | 11500 | 32.2 | 22.08 | 57.22 | 1.8830 | 0.03606 |
| | | | | | 12000 | 32.7 | 22.70 | 60.26 | 1.8928 | 0.03607 |
| | | | | LT 245 75R 17 AT | 6500 | 27.8 | 14.46 | 29.15 | 1.7923 | 0.03596 |
| | | | | | 7000 | 28.4 | 15.27 | 32.59 | 1.8034 | 0.03597 |
| | | | | | 7500 | 28.9 | 16.06 | 36.01 | 1.8144 | 0.03598 |
| | | | | | 8000 | 29.4 | 16.82 | 39.41 | 1.8253 | 0.03600 |
| | | | | | 8500 | 29.9 | 17.55 | 42.78 | 1.8362 | 0.03601 |
| | | | | | 9000 | 30.5 | 18.26 | 46.14 | 1.8470 | 0.03602 |
| | | | | | 9500 | 31.0 | 18.95 | 49.48 | 1.8577 | 0.03603 |
| | | | | | 10000 | 31.5 | 19.62 | 52.80 | 1.8684 | 0.03604 |
| | | | | | 10500 | 32.0 | 20.27 | 56.10 | 1.8790 | 0.03606 |
| | | | | | 11000 | 32.5 | 20.90 | 59.39 | 1.8896 | 0.03607 |
| | | | | | 11500 | 33.1 | 21.51 | 62.67 | 1.9002 | 0.03608 |
| | | | | | 12000 | 33.6 | 22.10 | 65.93 | 1.9106 | 0.03609 |
| All F350/450 DRW | 6.7L Diesel | Auto | 4x4 | LT 245 75R 17 AS | 7000 | 28.1 | 15.40 | 30.13 | 1.7925 | 0.03645 |
| 40.5 sq. ft. | | | | | 7500 | 28.6 | 16.22 | 33.32 | 1.8028 | 0.03646 |
| | | | | | 8000 | 29.1 | 17.00 | 36.49 | 1.8130 | 0.03647 |
| | | | | | 8500 | 29.6 | 17.76 | 39.64 | 1.8232 | 0.03649 |
| | | | | | 9000 | 30.1 | 18.50 | 42.77 | 1.8333 | 0.03650 |
| | | | | | 9500 | 30.6 | 19.21 | 45.89 | 1.8433 | 0.03651 |
| | | | | | 10000 | 31.1 | 19.91 | 48.99 | 1.8533 | 0.03652 |
| | | | | | 10500 | 31.5 | 20.58 | 52.08 | 1.8633 | 0.03653 |
| | | | | | 11000 | 32.0 | 21.24 | 55.15 | 1.8732 | 0.03654 |
| | | | | | 11500 | 32.5 | 21.88 | 58.21 | 1.8830 | 0.03655 |
| | | | | | 12000 | 33.0 | 22.50 | 61.25 | 1.8928 | 0.03656 |
| | | | | | 12500 | 33.4 | 23.10 | 64.28 | 1.9026 | 0.03657 |
| | | | | LT 245 75R 17 AT | 7000 | 28.7 | 15.11 | 33.58 | 1.8034 | 0.03646 |
| | | | | | 7500 | 29.2 | 15.89 | 37.00 | 1.8144 | 0.03648 |
| | | | | | 8000 | 29.7 | 16.65 | 40.39 | 1.8253 | 0.03649 |

## ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350 Completes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 8500 | 30.2 | 17.38 | 43.77 | 1.8362 | 0.03650 |
| | | | | | 9000 | 30.8 | 18.09 | 47.12 | 1.8470 | 0.03651 |
| | | | | | 9500 | 31.3 | 18.77 | 50.46 | 1.8577 | 0.03652 |
| | | | | | 10000 | 31.8 | 19.44 | 53.78 | 1.8684 | 0.03654 |
| | | | | | 10500 | 32.3 | 20.08 | 57.09 | 1.8790 | 0.03655 |
| | | | | | 11000 | 32.8 | 20.71 | 60.38 | 1.8896 | 0.03656 |
| | | | | | 11500 | 33.3 | 21.32 | 63.65 | 1.9002 | 0.03657 |
| | | | | | 12000 | 33.9 | 21.91 | 66.91 | 1.9106 | 0.03658 |
| | | | | | 12500 | 34.4 | 22.48 | 70.16 | 1.9211 | 0.03660 |
| All F350/450 DRW | 6.7L Diesel | Auto | 4x4 | LT 245 75R 17 AS | 7000 | 32.2 | 13.47 | 30.13 | 1.7925 | 0.04860 |
| 51 sq. ft. | | | | | 7500 | 32.7 | 14.21 | 33.32 | 1.8028 | 0.04861 |
| | | | | | 8000 | 33.2 | 14.93 | 36.49 | 1.8130 | 0.04862 |
| | | | | | 8500 | 33.7 | 15.63 | 39.64 | 1.8232 | 0.04864 |
| | | | | | 9000 | 34.1 | 16.31 | 42.77 | 1.8333 | 0.04865 |
| | | | | | 9500 | 34.6 | 16.97 | 45.89 | 1.8433 | 0.04866 |
| | | | | | 10000 | 35.1 | 17.62 | 48.99 | 1.8533 | 0.04867 |
| | | | | | 10500 | 35.6 | 18.25 | 52.08 | 1.8633 | 0.04868 |
| | | | | | 11000 | 36.1 | 18.86 | 55.15 | 1.8732 | 0.04869 |
| | | | | | 11500 | 36.5 | 19.46 | 58.21 | 1.8830 | 0.04870 |
| | | | | | 12000 | 37.0 | 20.05 | 61.25 | 1.8928 | 0.04871 |
| | | | | | 12500 | 37.5 | 20.62 | 64.28 | 1.9026 | 0.04872 |
| | | | | LT 245 75R 17 AT | 7000 | 32.7 | 13.25 | 33.58 | 1.8034 | 0.04861 |
| | | | | | 7500 | 33.2 | 13.96 | 37.00 | 1.8144 | 0.04863 |
| | | | | | 8000 | 33.8 | 14.66 | 40.39 | 1.8253 | 0.04864 |
| | | | | | 8500 | 34.3 | 15.34 | 43.77 | 1.8362 | 0.04865 |
| | | | | | 9000 | 34.8 | 15.99 | 47.12 | 1.8470 | 0.04866 |
| | | | | | 9500 | 35.3 | 16.63 | 50.46 | 1.8577 | 0.04867 |
| | | | | | 10000 | 35.9 | 17.25 | 53.78 | 1.8684 | 0.04869 |
| | | | | | 10500 | 36.4 | 17.85 | 57.09 | 1.8790 | 0.04870 |
| | | | | | 11000 | 36.9 | 18.44 | 60.38 | 1.8896 | 0.04871 |
| | | | | | 11500 | 37.4 | 19.02 | 63.65 | 1.9002 | 0.04872 |
| | | | | | 12000 | 37.9 | 19.58 | 66.91 | 1.9106 | 0.04873 |
| | | | | | 12500 | 38.4 | 20.12 | 70.16 | 1.9211 | 0.04875 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 F250/350/450 Incompletes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients 3-Term | | f0 | f1 | f2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| F250/F350 SRW | 6.2L | Auto | 4x2 | LT 245 75R 17 AS | 8000 | 50.2 | 9.88 | 44.57 | 0.9099 | 0.11468 |
| Incomplete | | | | | 8500 | 50.7 | 10.39 | 47.71 | 0.9200 | 0.11469 |
| 72 sq. ft. | | | | | 9000 | 51.2 | 10.90 | 50.83 | 0.9300 | 0.11470 |
| | | | | | 9500 | 51.7 | 11.39 | 53.93 | 0.9400 | 0.11471 |
| | | | | | 10000 | 52.2 | 11.88 | 57.02 | 0.9500 | 0.11473 |
| | | | | | 10500 | 52.7 | 12.36 | 60.09 | 0.9599 | 0.11474 |
| | | | | | 11000 | 53.1 | 12.83 | 63.15 | 0.9697 | 0.11475 |
| | | | | | 11500 | 53.6 | 13.29 | 66.19 | 0.9795 | 0.11476 |
| | | | | | 12000 | 54.1 | 13.75 | 69.23 | 0.9893 | 0.11477 |
| | | | | | 12500 | 54.6 | 14.20 | 72.24 | 0.9990 | 0.11478 |
| | | | | | 13000 | 55.0 | 14.64 | 75.25 | 1.0087 | 0.11479 |
| | | | | | 13500 | 55.5 | 15.07 | 78.25 | 1.0183 | 0.11480 |
| | | | | LT 265 70R 17 AT | 8000 | 50.9 | 9.74 | 50.99 | 0.8453 | 0.11548 |
| | | | | | 8500 | 51.5 | 10.24 | 54.58 | 0.8521 | 0.11554 |
| | | | | | 9000 | 52.0 | 10.73 | 58.16 | 0.8589 | 0.11560 |
| | | | | | 9500 | 52.6 | 11.20 | 61.71 | 0.8656 | 0.11566 |
| | | | | | 10000 | 53.1 | 11.67 | 65.26 | 0.8724 | 0.11572 |
| | | | | | 10500 | 53.6 | 12.13 | 68.79 | 0.8791 | 0.11578 |
| | | | | | 11000 | 54.2 | 12.58 | 72.30 | 0.8857 | 0.11584 |
| | | | | | 11500 | 54.7 | 13.03 | 75.81 | 0.8924 | 0.11589 |
| | | | | | 12000 | 55.2 | 13.46 | 79.30 | 0.8990 | 0.11595 |
| | | | | | 12500 | 55.7 | 13.89 | 82.79 | 0.9056 | 0.11601 |
| | | | | | 13000 | 56.3 | 14.31 | 86.26 | 0.9122 | 0.11607 |
| | | | | | 13500 | 56.8 | 14.72 | 89.72 | 0.9188 | 0.11613 |
| | | | | LT 275 65R 18 AS | 8000 | 51.4 | 9.65 | 57.64 | 0.7699 | 0.11564 |
| | | | | | 8500 | 51.9 | 10.15 | 61.52 | 0.7730 | 0.11571 |
| | | | | | 9000 | 52.5 | 10.63 | 65.39 | 0.7762 | 0.11578 |
| | | | | | 9500 | 53.0 | 11.10 | 69.24 | 0.7793 | 0.11585 |
| | | | | | 10000 | 53.6 | 11.56 | 73.06 | 0.7824 | 0.11592 |
| | | | | | 10500 | 54.1 | 12.01 | 76.87 | 0.7855 | 0.11599 |
| | | | | | 11000 | 54.7 | 12.46 | 80.66 | 0.7886 | 0.11605 |
| | | | | | 11500 | 55.2 | 12.89 | 84.43 | 0.7916 | 0.11612 |
| | | | | | 12000 | 55.8 | 13.32 | 88.18 | 0.7947 | 0.11619 |
| | | | | | 12500 | 56.3 | 13.74 | 91.92 | 0.7977 | 0.11626 |
| | | | | | 13000 | 56.9 | 14.16 | 95.65 | 0.8008 | 0.11632 |
| | | | | | 13500 | 57.4 | 14.56 | 99.36 | 0.8038 | 0.11639 |
| F250/F350 SRW | 6.7L Diesel | Auto | 4x2 | LT 245 75R 17 AS | 8000 | 50.4 | 9.85 | 45.56 | 0.9099 | 0.11468 |
| Incomplete | | | | | 8500 | 50.9 | 10.36 | 48.70 | 0.9200 | 0.11469 |
| 72 sq. ft. | | | | | 9000 | 51.3 | 10.87 | 51.82 | 0.9300 | 0.11470 |
| | | | | | 9500 | 51.8 | 11.36 | 54.92 | 0.9400 | 0.11471 |
| | | | | | 10000 | 52.3 | 11.85 | 58.01 | 0.9500 | 0.11473 |
| | | | | | 10500 | 52.8 | 12.33 | 61.08 | 0.9599 | 0.11474 |
| | | | | | 11000 | 53.3 | 12.80 | 64.14 | 0.9697 | 0.11475 |
| | | | | | 11500 | 53.7 | 13.26 | 67.18 | 0.9795 | 0.11476 |
| | | | | | 12000 | 54.2 | 13.71 | 70.21 | 0.9893 | 0.11477 |
| | | | | | 12500 | 54.7 | 14.16 | 73.23 | 0.9990 | 0.11478 |
| | | | | | 13000 | 55.2 | 14.60 | 76.24 | 1.0087 | 0.11479 |
| | | | | | 13500 | 55.6 | 15.03 | 79.23 | 1.0183 | 0.11480 |
| | | | | LT 265 70R 17 AT | 8000 | 51.1 | 9.71 | 51.98 | 0.8453 | 0.11548 |
| | | | | | 8500 | 51.6 | 10.21 | 55.56 | 0.8521 | 0.11554 |
| | | | | | 9000 | 52.1 | 10.70 | 59.14 | 0.8589 | 0.11560 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 9500 | 52.7 | 11.18 | 62.70 | 0.8656 | 0.11566 |
| | | | | | 10000 | 53.2 | 11.64 | 66.24 | 0.8724 | 0.11572 |
| | | | | | 10500 | 53.8 | 12.10 | 69.77 | 0.8791 | 0.11578 |
| | | | | | 11000 | 54.3 | 12.55 | 73.29 | 0.8857 | 0.11584 |
| | | | | | 11500 | 54.8 | 13.00 | 76.79 | 0.8924 | 0.11589 |
| | | | | | 12000 | 55.3 | 13.43 | 80.28 | 0.8990 | 0.11595 |
| | | | | | 12500 | 55.9 | 13.86 | 83.77 | 0.9056 | 0.11601 |
| | | | | | 13000 | 56.4 | 14.27 | 87.24 | 0.9122 | 0.11607 |
| | | | | | 13500 | 56.9 | 14.68 | 90.70 | 0.9188 | 0.11613 |
| | | | | LT 275 65R 18 AS | 8000 | 51.5 | 9.63 | 58.60 | 0.7699 | 0.11564 |
| | | | | | 8500 | 52.1 | 10.12 | 62.49 | 0.7730 | 0.11571 |
| | | | | | 9000 | 52.6 | 10.60 | 66.36 | 0.7762 | 0.11578 |
| | | | | | 9500 | 53.2 | 11.07 | 70.20 | 0.7793 | 0.11585 |
| | | | | | 10000 | 53.7 | 11.53 | 74.03 | 0.7824 | 0.11592 |
| | | | | | 10500 | 54.3 | 11.98 | 77.83 | 0.7855 | 0.11599 |
| | | | | | 11000 | 54.8 | 12.43 | 81.62 | 0.7886 | 0.11605 |
| | | | | | 11500 | 55.4 | 12.86 | 85.40 | 0.7916 | 0.11612 |
| | | | | | 12000 | 55.9 | 13.29 | 89.15 | 0.7947 | 0.11619 |
| | | | | | 12500 | 56.5 | 13.71 | 92.89 | 0.7977 | 0.11626 |
| | | | | | 13000 | 57.0 | 14.12 | 96.62 | 0.8008 | 0.11632 |
| | | | | | 13500 | 57.5 | 14.53 | 100.33 | 0.8038 | 0.11639 |
| F350 DRW | 6.2L | Auto | 4x2 | LT 245 75R 17 AS | 8000 | 50.6 | 9.80 | 47.01 | 0.9145 | 0.11469 |
| Incomplete | | | | | 8500 | 51.1 | 10.31 | 50.23 | 0.9249 | 0.11470 |
| 72 sq. ft. | | | | | 9000 | 51.6 | 10.81 | 53.43 | 0.9352 | 0.11471 |
| | | | | | 9500 | 52.1 | 11.30 | 56.61 | 0.9455 | 0.11472 |
| | | | | | 10000 | 52.6 | 11.79 | 59.78 | 0.9557 | 0.11473 |
| | | | | | 10500 | 53.1 | 12.26 | 62.94 | 0.9658 | 0.11474 |
| | | | | | 11000 | 53.6 | 12.72 | 66.08 | 0.9760 | 0.11475 |
| | | | | | 11500 | 54.1 | 13.18 | 69.20 | 0.9860 | 0.11477 |
| | | | | | 12000 | 54.5 | 13.63 | 72.31 | 0.9960 | 0.11478 |
| | | | | | 12500 | 55.0 | 14.07 | 75.41 | 1.0060 | 0.11479 |
| | | | | | 13000 | 55.5 | 14.51 | 78.50 | 1.0160 | 0.11480 |
| | | | | | 13500 | 56.0 | 14.94 | 81.57 | 1.0259 | 0.11481 |
| F350/F450 DRW | 6.7L Diesel | Auto | 4x2 | LT 245 75R 17 AS | 8000 | 50.9 | 9.75 | 48.98 | 0.9145 | 0.11469 |
| Incomplete | | | | | 8500 | 51.4 | 10.26 | 52.20 | 0.9249 | 0.11470 |
| 72 sq. ft. | | | | | 9000 | 51.9 | 10.76 | 55.40 | 0.9352 | 0.11471 |
| | | | | | 9500 | 52.4 | 11.25 | 58.59 | 0.9455 | 0.11472 |
| | | | | | 10000 | 52.8 | 11.73 | 61.75 | 0.9557 | 0.11473 |
| | | | | | 10500 | 53.3 | 12.20 | 64.91 | 0.9658 | 0.11474 |
| | | | | | 11000 | 53.8 | 12.66 | 68.05 | 0.9760 | 0.11475 |
| | | | | | 11500 | 54.3 | 13.12 | 71.17 | 0.9860 | 0.11477 |
| | | | | | 12000 | 54.8 | 13.56 | 74.28 | 0.9960 | 0.11478 |
| | | | | | 12500 | 55.3 | 14.01 | 77.38 | 1.0060 | 0.11479 |
| | | | | | 13000 | 55.8 | 14.44 | 80.47 | 1.0160 | 0.11480 |
| | | | | | 13500 | 56.2 | 14.86 | 83.55 | 1.0259 | 0.11481 |
| F250/F350 SRW | 6.2L | Auto | 4x4 | LT 245 75R 17 AS | 8000 | 51.6 | 9.61 | 33.07 | 1.8084 | 0.10547 |
| Incomplete | | | | | 8500 | 52.1 | 10.11 | 36.14 | 1.8183 | 0.10548 |
| 72 sq. ft. | | | | | 9000 | 52.6 | 10.61 | 39.19 | 1.8281 | 0.10549 |
| | | | | | 9500 | 53.0 | 11.10 | 42.22 | 1.8379 | 0.10550 |
| | | | | | 10000 | 53.5 | 11.58 | 45.24 | 1.8476 | 0.10551 |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 10500 | 54.0 | 12.05 | 48.25 | 1.8573 | 0.10552 |
| | | | | | 11000 | 54.5 | 12.52 | 51.24 | 1.8669 | 0.10553 |
| | | | | | 11500 | 54.9 | 12.97 | 54.21 | 1.8765 | 0.10555 |
| | | | | | 12000 | 55.4 | 13.42 | 57.18 | 1.8860 | 0.10556 |
| | | | | | 12500 | 55.8 | 13.87 | 60.13 | 1.8956 | 0.10557 |
| | | | | | 13000 | 56.3 | 14.30 | 63.07 | 1.9050 | 0.10558 |
| | | | | | 13500 | 56.8 | 14.73 | 66.00 | 1.9145 | 0.10559 |
| | | | | LT 265 70R 17 AT | 8000 | 52.3 | 9.48 | 39.26 | 1.7359 | 0.10642 |
| | | | | | 8500 | 52.8 | 9.98 | 42.76 | 1.7426 | 0.10647 |
| | | | | | 9000 | 53.3 | 10.46 | 46.25 | 1.7492 | 0.10653 |
| | | | | | 9500 | 53.9 | 10.93 | 49.72 | 1.7558 | 0.10659 |
| | | | | | 10000 | 54.4 | 11.39 | 53.18 | 1.7623 | 0.10665 |
| | | | | | 10500 | 54.9 | 11.85 | 56.62 | 1.7689 | 0.10670 |
| | | | | | 11000 | 55.4 | 12.29 | 60.06 | 1.7754 | 0.10676 |
| | | | | | 11500 | 56.0 | 12.73 | 63.48 | 1.7819 | 0.10682 |
| | | | | | 12000 | 56.5 | 13.16 | 66.89 | 1.7884 | 0.10687 |
| | | | | | 12500 | 57.0 | 13.59 | 70.28 | 1.7948 | 0.10693 |
| | | | | | 13000 | 57.5 | 14.00 | 73.67 | 1.8012 | 0.10699 |
| | | | | | 13500 | 58.0 | 14.41 | 77.05 | 1.8076 | 0.10704 |
| | | | | LT 275 70R 18 AT | 8000 | 54.0 | 9.17 | 50.12 | 1.7413 | 0.10725 |
| | | | | | 8500 | 54.7 | 9.63 | 54.16 | 1.7562 | 0.10726 |
| | | | | | 9000 | 55.3 | 10.08 | 58.17 | 1.7709 | 0.10728 |
| | | | | | 9500 | 56.0 | 10.52 | 62.17 | 1.7856 | 0.10730 |
| | | | | | 10000 | 56.6 | 10.94 | 66.14 | 1.8002 | 0.10731 |
| | | | | | 10500 | 57.2 | 11.36 | 70.09 | 1.8147 | 0.10733 |
| | | | | | 11000 | 57.8 | 11.77 | 74.03 | 1.8292 | 0.10735 |
| | | | | | 11500 | 58.5 | 12.18 | 77.95 | 1.8436 | 0.10736 |
| | | | | | 12000 | 59.1 | 12.57 | 81.85 | 1.8579 | 0.10738 |
| | | | | | 12500 | 59.7 | 12.96 | 85.74 | 1.8722 | 0.10740 |
| | | | | | 13000 | 60.3 | 13.34 | 89.61 | 1.8864 | 0.10741 |
| | | | | | 13500 | 60.9 | 13.71 | 93.47 | 1.9006 | 0.10743 |
| | | | | LT 275 65R 20 AT | 8000 | 53.7 | 9.23 | 51.39 | 1.5233 | 0.11004 |
| | | | | | 8500 | 54.3 | 9.69 | 55.63 | 1.5301 | 0.11018 |
| | | | | | 9000 | 55.0 | 10.14 | 59.86 | 1.5369 | 0.11032 |
| | | | | | 9500 | 55.6 | 10.57 | 64.07 | 1.5436 | 0.11045 |
| | | | | | 10000 | 56.3 | 11.00 | 68.27 | 1.5503 | 0.11059 |
| | | | | | 10500 | 56.9 | 11.42 | 72.45 | 1.5569 | 0.11072 |
| | | | | | 11000 | 57.6 | 11.83 | 76.63 | 1.5636 | 0.11086 |
| | | | | | 11500 | 58.2 | 12.23 | 80.78 | 1.5702 | 0.11099 |
| | | | | | 12000 | 58.9 | 12.62 | 84.93 | 1.5768 | 0.11113 |
| | | | | | 12500 | 59.5 | 13.00 | 89.07 | 1.5834 | 0.11126 |
| | | | | | 13000 | 60.2 | 13.38 | 93.19 | 1.5900 | 0.11140 |
| | | | | | 13500 | 60.8 | 13.74 | 97.31 | 1.5966 | 0.11153 |
| F250/F350 SRW | 6.7L Diesel | Auto | 4x4 | LT 245 75R 17 AS | 8000 | 51.8 | 9.58 | 34.06 | 1.8084 | 0.10547 |
| Incomplete | | | | | 8500 | 52.2 | 10.09 | 37.12 | 1.8183 | 0.10548 |
| 72 sq. ft. | | | | | 9000 | 52.7 | 10.58 | 40.17 | 1.8281 | 0.10549 |
| | | | | | 9500 | 53.2 | 11.07 | 43.21 | 1.8379 | 0.10550 |
| | | | | | 10000 | 53.7 | 11.55 | 46.23 | 1.8476 | 0.10551 |
| | | | | | 10500 | 54.1 | 12.02 | 49.23 | 1.8573 | 0.10552 |
| | | | | | 11000 | 54.6 | 12.49 | 52.22 | 1.8669 | 0.10553 |
| | | | | | 11500 | 55.1 | 12.94 | 55.20 | 1.8765 | 0.10555 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

## *2013 F250/350/450 Incompletes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | | 12000 | 55.5 | 13.39 | 58.16 | 1.8860 | 0.10556 |
| | | | | | 12500 | 56.0 | 13.83 | 61.12 | 1.8956 | 0.10557 |
| | | | | | 13000 | 56.4 | 14.27 | 64.06 | 1.9050 | 0.10558 |
| | | | | | 13500 | 56.9 | 14.70 | 66.99 | 1.9145 | 0.10559 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350/450 Incompletes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| | | | | LT 265 70R 17 AT | 8000 | 52.4 | 9.46 | 40.24 | 1.7359 | 0.10642 |
| | | | | | 8500 | 52.9 | 9.95 | 43.74 | 1.7426 | 0.10647 |
| | | | | | 9000 | 53.5 | 10.43 | 47.23 | 1.7492 | 0.10653 |
| | | | | | 9500 | 54.0 | 10.90 | 50.70 | 1.7558 | 0.10659 |
| | | | | | 10000 | 54.5 | 11.36 | 54.16 | 1.7623 | 0.10665 |
| | | | | | 10500 | 55.0 | 11.82 | 57.61 | 1.7689 | 0.10670 |
| | | | | | 11000 | 55.6 | 12.26 | 61.04 | 1.7754 | 0.10676 |
| | | | | | 11500 | 56.1 | 12.70 | 64.46 | 1.7819 | 0.10682 |
| | | | | | 12000 | 56.6 | 13.13 | 67.87 | 1.7884 | 0.10687 |
| | | | | | 12500 | 57.1 | 13.55 | 71.27 | 1.7948 | 0.10693 |
| | | | | | 13000 | 57.6 | 13.97 | 74.65 | 1.8012 | 0.10699 |
| | | | | | 13500 | 58.1 | 14.38 | 78.03 | 1.8076 | 0.10704 |
| | | | | LT 275 70R 18 AT | 8000 | 54.2 | 9.15 | 51.06 | 1.7413 | 0.10725 |
| | | | | | 8500 | 54.8 | 9.61 | 55.10 | 1.7562 | 0.10726 |
| | | | | | 9000 | 55.4 | 10.05 | 59.11 | 1.7709 | 0.10728 |
| | | | | | 9500 | 56.1 | 10.49 | 63.10 | 1.7856 | 0.10730 |
| | | | | | 10000 | 56.7 | 10.92 | 67.08 | 1.8002 | 0.10731 |
| | | | | | 10500 | 57.3 | 11.34 | 71.03 | 1.8147 | 0.10733 |
| | | | | | 11000 | 58.0 | 11.75 | 74.96 | 1.8292 | 0.10735 |
| | | | | | 11500 | 58.6 | 12.15 | 78.88 | 1.8436 | 0.10736 |
| | | | | | 12000 | 59.2 | 12.55 | 82.79 | 1.8579 | 0.10738 |
| | | | | | 12500 | 59.8 | 12.93 | 86.67 | 1.8722 | 0.10740 |
| | | | | | 13000 | 60.5 | 13.31 | 90.54 | 1.8864 | 0.10741 |
| | | | | | 13500 | 61.1 | 13.68 | 94.40 | 1.9006 | 0.10743 |
| | | | | LT 275 65R 20 AT | 8000 | 53.8 | 9.21 | 52.30 | 1.5233 | 0.11004 |
| | | | | | 8500 | 54.5 | 9.67 | 56.54 | 1.5301 | 0.11018 |
| | | | | | 9000 | 55.1 | 10.12 | 60.77 | 1.5369 | 0.11032 |
| | | | | | 9500 | 55.8 | 10.55 | 64.98 | 1.5436 | 0.11045 |
| | | | | | 10000 | 56.4 | 10.98 | 69.18 | 1.5503 | 0.11059 |
| | | | | | 10500 | 57.1 | 11.39 | 73.37 | 1.5569 | 0.11072 |
| | | | | | 11000 | 57.7 | 11.80 | 77.54 | 1.5636 | 0.11086 |
| | | | | | 11500 | 58.4 | 12.20 | 81.70 | 1.5702 | 0.11099 |
| | | | | | 12000 | 59.0 | 12.59 | 85.84 | 1.5768 | 0.11113 |
| | | | | | 12500 | 59.6 | 12.98 | 89.98 | 1.5834 | 0.11126 |
| | | | | | 13000 | 60.3 | 13.35 | 94.10 | 1.5900 | 0.11140 |
| | | | | | 13500 | 60.9 | 13.72 | 98.22 | 1.5966 | 0.11153 |
| F350 DRW | 6.2L | Auto | 4x4 | LT 245 75R 17 | 8000 | 52.3 | 9.48 | 37.45 | 1.8191 | 0.10548 |
| Incomplete | | | | | 8500 | 52.8 | 9.98 | 40.72 | 1.8296 | 0.10549 |
| 72 sq. ft. | | | | | 9000 | 53.3 | 10.47 | 43.96 | 1.8401 | 0.10550 |
| | | | | | 9500 | 53.8 | 10.94 | 47.19 | 1.8505 | 0.10552 |
| | | | | | 10000 | 54.3 | 11.41 | 50.40 | 1.8608 | 0.10553 |
| | | | | | 10500 | 54.8 | 11.87 | 53.60 | 1.8711 | 0.10554 |
| | | | | | 11000 | 55.3 | 12.32 | 56.78 | 1.8813 | 0.10555 |
| | | | | | 11500 | 55.8 | 12.77 | 59.94 | 1.8915 | 0.10556 |
| | | | | | 12000 | 56.3 | 13.21 | 63.10 | 1.9016 | 0.10557 |
| | | | | | 12500 | 56.8 | 13.64 | 66.24 | 1.9118 | 0.10558 |
| | | | | | 13000 | 57.3 | 14.06 | 69.37 | 1.9218 | 0.10560 |
| | | | | | 13500 | 57.7 | 14.48 | 72.48 | 1.9318 | 0.10561 |

ROADLOAD CERTIFICATION SPECIFICATIONS *2013 F250/350/450 Incompletes*

| Coverage Chart | Date | RDM file | Version | Comments |
|---|---|---|---|---|
| 13_P473_chart.xls | 8/19/2011 | 13_P473_4x2/4x4_inc.RDM.xls | 43 | New Track |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| F350/F450 DRW | 6.7L Diesel | Auto | 4x4 | LT 245 75R 17 | 8000 | 52.5 | 9.44 | 39.43 | 1.8191 | 0.10548 |
| Incomplete | | | | | 8500 | 53.1 | 9.93 | 42.69 | 1.8296 | 0.10549 |
| 72 sq. ft. | | | | | 9000 | 53.6 | 10.41 | 45.93 | 1.8401 | 0.10550 |
| | | | | | 9500 | 54.1 | 10.89 | 49.16 | 1.8505 | 0.10552 |
| | | | | | 10000 | 54.6 | 11.35 | 52.37 | 1.8608 | 0.10553 |
| | | | | | 10500 | 55.1 | 11.81 | 55.57 | 1.8711 | 0.10554 |
| | | | | | 11000 | 55.6 | 12.26 | 58.75 | 1.8813 | 0.10555 |
| | | | | | 11500 | 56.1 | 12.71 | 61.92 | 1.8915 | 0.10556 |
| | | | | | 12000 | 56.5 | 13.14 | 65.07 | 1.9016 | 0.10557 |
| | | | | | 12500 | 57.0 | 13.57 | 68.21 | 1.9118 | 0.10558 |
| | | | | | 13000 | 57.5 | 13.99 | 71.34 | 1.9218 | 0.10560 |
| | | | | | 13500 | 58.0 | 14.41 | 74.45 | 1.9318 | 0.10561 |

## ROADLOAD CERTIFICATION SPECIFICATIONS

*2013 Navigator*

| Coverage Chart | Date | RDM file | Comments |
|---|---|---|---|
| 13U228_chart.1_xls | 10/10/2011 | 11U228RDMVer43_4x2/4x4_3.xls | C/O 2011 MY |

| Vehicle Description | | | | | | Track Coefficients | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3-Term | | f0 | f1 | f2 |
| Body | Eng | Trans | Drive | Tire | ETW | HP@50 | 55-45 CDT | lbf | lbf/mph | lbf/mph^2 |
| Navigator | 5.4L | Auto | 4x2 | P 255 70R 18 AS | 6000 | 21.5 | 17.23 | 47.64 | 0.5185 | 0.03517 |
| | | | | | 6500 | 22.2 | 18.12 | 51.88 | 0.5302 | 0.03519 |
| | | | | | 7000 | 22.8 | 18.95 | 56.14 | 0.5419 | 0.03521 |
| | | | | P 275 55R 20 AS | 6000 | 21.5 | 17.24 | 47.21 | 0.5184 | 0.03530 |
| | | | | | 6500 | 22.2 | 18.10 | 51.60 | 0.5304 | 0.03534 |
| | | | | | 7000 | 22.9 | 18.91 | 56.04 | 0.5424 | 0.03538 |
| | | | | P 285 45R 22 | 6000 | 22.0 | 16.84 | 50.47 | 0.5195 | 0.03551 |
| | | | | | 6500 | 22.7 | 17.70 | 54.78 | 0.5308 | 0.03556 |
| | | | | | 7000 | 23.4 | 18.52 | 59.08 | 0.5421 | 0.03561 |
| Navigator Long | 5.4L | Auto | 4x2 | P 255 70R 18 AS | 6000 | 21.8 | 17.02 | 47.64 | 0.5185 | 0.03597 |
| | | | | | 6500 | 22.4 | 17.90 | 51.88 | 0.5302 | 0.03599 |
| | | | | | 7000 | 23.1 | 18.73 | 56.14 | 0.5419 | 0.03600 |
| | | | | P 275 55R 20 AS | 6000 | 21.8 | 17.03 | 47.21 | 0.5184 | 0.03610 |
| | | | | | 6500 | 22.5 | 17.89 | 51.60 | 0.5304 | 0.03614 |
| | | | | | 7000 | 23.1 | 18.70 | 56.04 | 0.5424 | 0.03617 |
| | | | | P 285 45R 22 | 6000 | 22.3 | 16.64 | 50.47 | 0.5195 | 0.03631 |
| | | | | | 6500 | 23.0 | 17.50 | 54.78 | 0.5308 | 0.03636 |
| | | | | | 7000 | 23.6 | 18.31 | 59.08 | 0.5421 | 0.03641 |
| Navigator Limo | 5.4L | Auto | 4x2 | P 255 70R 18 AS | 8500 | 25.1 | 20.94 | 69.03 | 0.5774 | 0.03606 |
| | | | | | 9000 | 25.7 | 21.60 | 73.36 | 0.5893 | 0.03608 |
| | | | | | 9500 | 26.4 | 22.23 | 77.70 | 0.6012 | 0.03610 |
| | | | | XL 285 60R 18 | 8500 | 24.2 | 21.66 | 65.85 | 0.5405 | 0.03558 |
| | | | | | 9000 | 24.8 | 22.42 | 69.59 | 0.5485 | 0.03558 |
| | | | | | 9500 | 25.3 | 23.15 | 73.33 | 0.5565 | 0.03558 |
| Navigator | 5.4L | Auto | 4x4 | P 255 70R 18 AS | 6000 | 23.7 | 15.62 | 56.56 | 0.9263 | 0.03006 |
| | | | | | 6500 | 24.4 | 16.47 | 60.80 | 0.9380 | 0.03008 |
| | | | | | 7000 | 25.0 | 17.27 | 65.06 | 0.9497 | 0.03010 |
| | | | | P 275 55R 20 AS | 6000 | 23.7 | 15.63 | 56.13 | 0.9279 | 0.03017 |
| | | | | | 6500 | 24.4 | 16.45 | 60.52 | 0.9398 | 0.03021 |
| | | | | | 7000 | 25.1 | 17.23 | 64.96 | 0.9518 | 0.03025 |
| | | | | P 285 45R 22 | 6000 | 24.2 | 15.30 | 59.39 | 0.9268 | 0.03041 |
| | | | | | 6500 | 24.9 | 16.13 | 63.69 | 0.9381 | 0.03046 |
| | | | | | 7000 | 25.6 | 16.91 | 68.00 | 0.9495 | 0.03051 |
| Navigator Long | 5.4L | Auto | 4x4 | P 255 70R 18 AS | 6000 | 23.9 | 15.53 | 56.56 | 0.9263 | 0.03046 |
| | | | | | 6500 | 24.5 | 16.38 | 60.80 | 0.9380 | 0.03048 |
| | | | | | 7000 | 25.2 | 17.18 | 65.06 | 0.9497 | 0.03050 |
| | | | | P 275 55R 20 AS | 6000 | 23.9 | 15.54 | 56.13 | 0.9279 | 0.03057 |
| | | | | | 6500 | 24.5 | 16.37 | 60.52 | 0.9398 | 0.03061 |
| | | | | | 7000 | 25.2 | 17.15 | 64.96 | 0.9518 | 0.03064 |
| | | | | P 285 45R 22 | 6000 | 24.4 | 15.21 | 59.39 | 0.9268 | 0.03081 |
| | | | | | 6500 | 25.0 | 16.04 | 63.69 | 0.9381 | 0.03086 |
| | | | | | 7000 | 25.7 | 16.83 | 68.00 | 0.9495 | 0.03090 |

# Coastdown Calculation Summary

## Track Testing

Ford conducts its track coastdown testing in accordance with SAE procedure J2263, *Roadload Measurement Using Onboard Anemometry and Coastdown Techniques*.

### Single-Roll Electric Dynamometer Applications

Deceleration data are fitted as follows: $-M\frac{dV}{dt} = F_o + F_1V + F_2V^2$.

## Dynamometer Testing

### Single-Roll Electric Dynamometer Applications

Ford conducts its single-roll dynamometer testing in accordance with SAE procedure J2264, *Chassis Dynamometer Simulation of Roadload Using Coastdown Techniques*. Dynamometer force is adjusted such that
$A + BV + CV^2 = (F_o - a) + (F_1 - b)V + (F_2 - c)V^2$, where ABC's are dynamometer coefficients, F-terms are target (track) coefficients, and abc's are vehicle loss coefficients.

## Roadload Determination using Analytical Methods

Ford uses analytical methods to establish many roadload parameters, as described in the letter mentioned above. In general, the method is performed as follows:

1. Perform actual coastdown/DPA test with a baseline vehicle.
2. Determine roadload impact of updated hardware using laboratory testing. Examples are listed below:
   - Tire change: Drums and twin-roll rolling resistance rigs are used to measure the new tire's rolling resistance. The change in rolling resistance may result in a change in total roadload.
   - Body change: A wind tunnel is used to measure the body change's effect on aerodynamic drag. The change in drag may result in a change in total roadload and DPA.
   - Transmission or driveline change: A single-roll dynamometer and wheel-mounted torque meters are used to determine the new hardware's effect on parasitic losses. The change in losses may result in a change in total roadload and/or DPA.
3. Using the data generated in steps 1 and 2, predict roadload parameters for a vehicle equipped with the new hardware.
4. Determine correlation between certification test site and bench test site.
5. Adjust numbers generated in step 3 using correlation data generated in step 4.
6. Routinely conduct audits to verify predicted parameters by performing coastdown/DPA testing on vehicle with correct hardware.

# Certification Dynamometer / Road Load Horsepower Procedures

Ford maintains the following roadload determination procedures, available upon request. The procedures have been based on SAE J2263 and J2264

**12.01.05.01 & 12.01.05.02** – Procedure for Determining the Road Load Horsepower for 48 in. 'Single' Roll Electric Dynamometers.
• CETP: 00.00-L-908

**12.01.06.00** – Certification Coast down Procedure for Determining Road Load Horsepower.
• CETP: 00.00-R-901

## 1.0 INTRODUCTION

This Corporate Engineering Test Procedure defines the method for determining the Power Exchange Unit (PEU) Road Load Horsepower Determination for 48 inch single roll electric dynamometers. This Procedure incorporates the requirements of the Code of Federal Regulations (CFR), Title 40, and the California Code of Regulations (CCR), Title 13. It also clarifies regulations and provides additional Ford/government policies to ensure quality data. In the event that differences exist, Corporate policies supersede regulations based on Agency approval and/or more stringent Ford tolerances. Referenced information may be obtained from Vehicle Environmental Engineering (VEE) upon request.

1.1 COMMONALITY. This is a CONTROL TEST and can be used to qualify vehicles or components throughout the world. The test may be conducted at any location having the necessary equipment and facilities. Proposed revisions to this procedure must be submitted per FAP03-179.

1.2 In the event that requirements are exceeded during testing, continue with testing and contact the customer for further direction.

## 2.0 INSTRUMENTATION

2.1 All test measurement equipment must be calibrated and maintained per FAP03-015, Control, Calibration, and Maintenance of Measurement and Test Equipment.

2.2 All applicable safety guidelines and procedures must be followed.

## 3.0 EQUIPMENT AND FACILITIES

3.1 Approved Ford emissions test facility in compliance with 40 CFR 86.106, "Equipment required, overview."

3.2 Equivalent equipment may be used if approved by the responsible management and VEE before the test is conducted. Note: VEE approval is not required for development methodalogies.

3.3 Smoking is allowed in designated smoking areas only.

3.4 Test vehicles cannot be exposed at any time during the test sequence to temperatures outside the 68° - 86°F range, unless determination is performed at another specified temperature.

3.5 Soak area requirements:

3.5.1 Soak area temperature must be monitored at constant intervals not more than one minute apart and be maintained at 72° ± 82°F. Temporary excursions within 68°- 86°F are allowed. For development and in-use testing, soak area must be maintained between 68°- 86°F. Soak area temperature may change based on temperature in which the determinaton is performed.

3.5.2 There must be no solar load or condensation on vehicles in soak areas.

3.6 Test site requirements:

3.6.1 Test site must be verified by the appropriate responsible activities as being applicable and ready for the type of test being performed.

3.6.2 Test site temperature control system must be set to maintain an average temperature of 75 ± 3°F measured continuously at the inlet to the cooling fan. Excursions are permitted (and would not result in a void test) provided they are temporary in nature and do not exceed 68°- 86°F. For development and in-use testing, the ambient temperature must be within 68°- 86°F throughout the entire test. Test site temperature may change based on temperature in which the determinaton is performed.

3.6.3 There must be no solar load on vehicles and equipment in the test site.

3.6.4 Test site should provide sufficient air circulation such that the dilution air inlet is within 68°- 86°F.

3.6.5 Ensure that the dynamometer is sufficiently warmed prior to the beginning of each shift that the dynamometer is used.

3.6.6 Cooling fan must be positioned vertically, squarely, and within 12 inches of the front bumper of the vehicle.

3.6.7 Additional cooling is not permitted without prior VEE approval, except for development testing. Request for additional cooling must be specified on the test request.

3.6.8 Cooling fan vehicle restraints, if used, must be positioned as close to the front bumper of the vehicle as possible without making contact.

3.6.9 The vehicle must be restrained to minimize horizontal movement. The restraints should place no more than a minimal vertical load (zero is preferred) on the drive wheels.

## 4.0 VEHICLE PREPARATION

4.1 Test vehicles must be configured, instrumented, inspected and approved as being ready for the applicable test by the appropriate responsible activities.

4.2 Prepare vehicle in compliance with 40 CFR 86.131, "Vehicle preparation" for certification testing.

4.3 Vehicle set-up criteria as applicable:

| VEHICLE SET-UP | DEVELOP | CERT | END-OF-LINE | IN-USE |
|---|---|---|---|---|
| Traction assist off/disconnected | x | x | x | x |
| Four wheel and all wheel drive disconnected | x | x | o | x |

| | | | | |
|---|---|---|---|---|
| All accessories turned off (unless otherwise noted) | x | x | x | x |
| Remove fuel tank shields for heat build | o | o | o | o |
| Vehicle ID label front/rear window | x | x | o | x |

| VEHICLE SET-UP | DEVELOP | CERT | END-OF-LINE | IN-USE |
|---|---|---|---|---|
| Marmon flange | x | x | o | |
| Environmental Altitude Test Chamber (EATC) (covered battery terminals, ignition interlock) | x | | | |
| OBD port | o | o | o | o |
| A/C disabled unless otherwise specified | x | x | x | |
| Point source probes | o | | | |
| Daytime running lamps disabled | o | sp[1] | | |
| Fuel tank drains | o | x | | x |
| Fuel tank thermocouples | o | x | | x |
| Exhaust pipe and silencer(s) weep holes plugged | x | x | | |
| Exhaust/catalyst sampling probes | o | sp[2] | | |
| Engine coolant temperature (ECT) thermocouple | o | o | | |
| Canister access | o | o | | |
| Air/Fuel meter probe with rubber cap | o | | | |
| EGR sampling probe with rubber cap | o | | | |
| Forced cool-down option allowed | o | | | |
| Soak canister | o | | o | o |
| Canister purge and load adapters | o | o | | o |
| Oil sump thermocouple | o | | | |
| For HEVs, ensure that the 12V battery is fully charged | x | x | x | x |
| Thermocouples installed in other locations | o | | | |

Note: **x** = required; **o** = optional; **blank** = not applicable; **sp** = special permission

4.4 Other criteria:

4.4.1 Cold tire pressure of drive wheels must be set to automotive manufacturer's recommended tire pressure. Cold tire pressure of non-drive wheels must be set at or between manufacturer's recommended tire pressure and 45 psi . If the manufacturer's recommended tire pressure is greater than 45 psi then the manufacturer's pressure must be used.

[1] Authorization provided under regulations 40 CFR 86.090-27
[2] Special approval from Certification Engineering prior to installation

4.4.2 Vehicles with manual transmissions must follow shift schedule supplied by the test requester. The manual shift schedule must be consistent with other shift schedules for exhaust and evaporative emissions test sequences.

4.4.3 Test vehicle must be approximately level during the PEU determination.

## 5.0 OPERATION

**Start**

**Fuel Drain & Fill**

Windows are closed.
Fill within 20 minutes of draining.[3]
Fuel delivery temperature 45°-80°F.
Fuel fill to 40% of usable/advertised fuel capacity (Usable/advertised fuel capacity is defined by Ford Trustmark Standards (WCR): System Design Specification (FU-1050) and determined by the volumetric difference between the Reported Actual Liquid Capacity (FU-1047) and the Reported Unusable Fuel Amount (FU-1049)[4]. For in-use testing use the Certification Application to determine 40% usable fuel capacity.
Fill and record to nearest 0.1 gallon. Fuel type specified on test request.
The fuel cap must be installed within one minute after fueling.
If the vehicle has more than one fuel tank, ensure each is filled. After fueling, fuel tank selector switch must be in primary tank position.

**Vehicle Soak**

Vehicle hood is closed and latched[5]. Ignition key in "off" position.
At the beginning of soak, set the drive wheel tire pressure to 5 psi above manufacturer's recommended tire pressure, unless otherwise requested.

**4 hours minimum**

[3] For end-of-line testing, this time limit does not apply.
[4] The fuel tank capacity design specification for usable capacity may be used for development testing if actual capacity is not available.
[5] When possible, for development only.

| | |
|---|---|
| **Preconditioning Drive** | Set tire pressure of drive wheels back to specification.<br>Center vehicle on the dynamometer with drive wheels perpendicular to dynamometer roll axis.<br>Vehicle hood open.<br>Enter in track coefficients.<br>Set the dynamometer with the vehicle equivalent test weight (ETW) and road load coefficients estimated from the following[6]:<br>$Dyno_{set}\ A_s = 0.5$ x track coefficients, $f_0$<br>$Dyno_{set}\ B_s = 0.2$ x track coefficients, $f_1$<br>$Dyno_{set}\ C_s = 1.0$ x track coefficients, $f_2$<br>Conduct two back-to-back HwFET cycles.<br>Roll count distance per cycle within 2.0% of theoretical: 10.3 miles. |

**30 seconds maximm**

| | |
|---|---|
| **PEU Road Load Horsepower Determination** | Driver must remain in the vehicle.<br>Shift the vehicle into neutral.<br>Turn ignition key to off position.<br>Open and close driver's door.<br>Dynamometer will accelerate the vehicle at 2 mph/sec to 75[7] mph and perform a coastdown from 75.0 to 9.0 ± 1.0 mph.<br>Measure time in 10 mph increments from 70.0 to 10.0 mph to the nearest 0.01 second.<br>Compare the $Dyno_{track}$ curve with the $Dyno_{measured}$ curve.<br>- If the curves are within ± 2.0 lbs. at all points, perform two more coastdowns for verification. All three must be within ± 2.0 lbs.<br>- If greater than ± 2.0 lbs. at any point, then reset the $Dyno_{set}$ coefficients by subtracting the $Dyno_{measured}$ coefficients of the previous coastdown from the $Dyno_{track}$ coefficients and adding the difference to their respective $dynamometer_{set}$ coefficients. Repeat up to 10 coastdowns, and evaluate runs until the ± 2.0 lbs. is met for three runs.<br>After 10 attempts, resoak the vehicle before making additional attempts.[8]<br>If the second verification run and the $Dyno_{set}$ curve is negative in the usable speed range, notify test requester, check for possible causes, document all actions taken, and proceed as follows:<br>- If a vehicle problem is discovered, notify requester.<br>- If a vehicle problem is not determined or if a negative load persists after |

[6] Obtain values from Certification Engineering, except for development testing.
[7] The speed range for determination may be modified based on the capacity of the vehicle.
[8] The estimated coefficient values should be rechecked before the next attempt.

the second road load derivation, then either this or an approved alternative road load derivation process may be used to attempt new coefficients.[9]

**End**

Perform all applicable calculations in Section 5.1 to 5.3.
After the dynamometer has adjusted the $Dyno_{set}$ coefficients to satisfy the difference criteria, calculate the vehicle drivetrain parasitic friction coefficients ($Dyno_{vehicle}$) by subtracting the $Dyno_{set}$ coefficients from the $Dyno_{measured}$ coefficients.

5.1 The "average" deceleration force through each speed interval is computed using the inertia weight and coastdown times recorded by the dynamometer computer.

$$F_{Avg} = \frac{M\,(lb_m) \times \Delta V\,(mi\,/\,hr)}{CDT_{Actual}\,(s)} \times \frac{5280\ ft}{mi} \times \frac{1hr}{3600\ \sec} \times \frac{1lb_f}{32.174\ lb_m\,ft\,/\,s^2}$$

5.1.1 Simplified:

$$F_{Avg} = \frac{M \times \Delta V}{21.937 \times CDT_{Actual}}$$

(M = highway inertia, $F_{Measured}$ = average force calculated from time and speed measurements, $CDT_{Actual}$ = measured coast down time over speed interval, ΔV = speed interval)

5.2 Perform the first error correction to account for the assumption of constant deceleration rate through a coastdown interval. This is done by first determining the interval coastdown time using the $Dyno_{set}$ coefficients.

$$CDT_{Expected} = \frac{M}{21.937} \times \int_{V_1}^{V_2} \frac{dV}{A + BV + CV^2}$$

5.2.1 Simplified:

$$CDT_{Expected} = \left[2\left(M/21.937\right)/\left(4AC - B^2\right)^{1/2}\right] \times \left[\arctan\left\{\left(2CV_2 + B\right)/\left(4AC - B^2\right)^{1/2}\right\} - \arctan\left\{\left(2CV_1 + B\right)/\left(4AC - B^2\right)^{1/2}\right\}\right]$$

[9] Negative loads may occur on new vehicles tested with coefficients determined from broken-in vehicles (typically 4000 mile vehicles). In such cases, negative loads are acceptable if a vehicle problem does not exist. Negative loads occur when $F=A_{set}+B_{set}V+C_{set}V^2 < 0$

(M = highway inertia, $V_2$ = speed at the beginning of the coastdown interval, $V_1$ = speed at the end of the coastdown interval)

5.2.2 Determine the expected average force over the interval.

$$F_{Exp,Avg} = \frac{M \times \Delta V}{21.937 \times CDT_{Expected}}$$

5.2.3 Determine the expected mid-point force using $Dyno_{set}$ coefficients and the mid-point velocity of each interval.

$$F_{Exp,Mid} = A + BV + CV^2$$

5.2.4 Calculate the partially corrected "approximate" force for each interval as follows:

$$F_{App} = F_{Avg} + (F_{Exp,Mid} - F_{Exp,Avg})$$

5.2.5 Calculate a quadratic regression on these approximate force values to give approximate coefficients $A_{app}$, $B_{app}$, & $C_{app}$.

5.3 Perform the second error correction by repeating the same calculation process as in the first error correction. However, set the $Dyno_{set}$ coefficients equal to the approximate coefficients and calculate the "actual" force using the same equations used to calculate the "approximate" force.

$$CDT_{Expected} = \frac{M}{21.937} \times \int_{V_1}^{V_2} \frac{dV}{A + BV + CV^2}$$

5.3.1 Simplified:

$$CDT_{Expected} = \left[2(M/21.937)/(4AC - B^2)^{1/2}\right] \times \left[\arctan\left\{(2CV_2 + B)/(4AC - B^2)^{1/2}\right\} - \arctan\left\{(2CV_1 + B)/(4AC - B^2)^{1/2}\right\}\right]$$

5.3.2 Then determine the expected average force over the interval.

$$F_{Exp,Avg} = \frac{M \times \Delta V}{21.937 \times CDT_{Expected}}$$

5.3.3 Now the expected mid-point force is determined using $Dyno_{App}$ coefficients and the mid-point velocity of each interval.

$$F_{exp} = A + BV + CV^2$$

5.3.4 Calculate the actual force for each interval as follows:

$$F_{Act} = F_{Avg} + (F_{Exp,Mid} - F_{Exp,Avg})$$

5.3.5 Run a quadratic regression on the actual forces to get the final $Dyno_{measured}$ coefficients.

## 6.0 GENERAL INSTRUCTIONS

6.1 Instructions to deviate from this CETP must be documented on the test request or by an approved change request.

6.2 This CETP does not apply to twin-roll dynamometers.

6.3 Coefficients determined at 68°- 86°F shall be used for testing at all laboratory temperatures unless otherwise requested. Ford reserves the right to derive coefficients at 20°F and 50°F.

6.4 During soak, the position of automatic windows can only be changed when the ignition key is in "accessory" mode.

6.5 Unless specifically stated the vehicle windows may be in any position.

## 7.0 PRESENTATION OF DATA

7.1 Provide data to requester as required per this CETP and applicable test request.

## 8.0 REFERENCES

8.1 FAP03-015, Control, Calibration, and Maintenance of Measurement and Test Equipment

8.2 FAP03-179, Developing Corporate Engineering Test Procedures

8.3 40 CFR Part 86, Subpart B; paragraphs 86.106-108, 113, 116, 118, 129, 131, 135, 142; Appendix I

8.4 40 CFR Part 600, Subpart B; paragraphs 600.107, 109-111

8.5 CCR, Title 13, Division 3, Chapter 1, 3

8.6 Applicable VEE Emission Laboratory Requirements (ELRs), including Vehicle Starting/Driving Criteria (ELR07P-105), Single Roll Electric Chassis Dynamometer Ready State Check (ELR07P-348).

8.7 Ford Trustmark Standards (WCR): System Design Specification (FU-1050), Reported Actual Liquid Capacity (FU-1047), and Reported Actual Unusable Fuel Amount (FU-1049).

8.8 Letter, "Ambient Coefficients Used for Cold CO Tests," February 28, 2000, from T. Fagerman to R. Sherby, et. al.

8.9 Letter, "Meeting Minutes – EPA/Ford Discussion about Single Roll Dynamometer and Quick Check," February 1, 2000, from E. Kulik to B. Bisaro, et. al.

8.10 EPA Dear Manufacturer Letter VPCD-98-16, "Single Roll Dynamometer Adjustment and Road Force Determination", December 21, 1998.

8.11 Letter, "Ford's New Procedures for the Determination and Application of Dynamometer Road Load Coefficients for Certification Testing," December 10, 1996, D. Kulp to T. Ball (EPA).

8.12 Letter, "Approval of Ford's New Procedures for the Determination and Application of Dynamometer Road Load Coefficients for Certification Testing", December 23, 1996, T. Ball (EPA) to D. Kulp.

8.13 SAE paper J2264, "Chassis Dynamometer Simulation of Road Load Using Coastdown Techniques," April 1995.

8.14 Letter, "Testing Vehicles Equipped with Daytime Running Lights," R. Maxwell (EPA), published February 9, 1994.

8.15 Letter, "Theoretical Distances for EPA-75 and HwFETs," November 30, 1993 from E. Smith (E&SE).

## 9.0 RECORD OF REVISIONS

See metadata field "Previous Review Notes".

## 1.0 INTRODUCTION

This procedure describes the method of obtaining the Coastdown time, the track road load coefficients (F0,F1,F2) and the 50 mph total road load horsepower for a vehicle to be used for determining alternate dynamometer road load horsepower settings (PAU) and electric 48" roll diameter dynamometer road load coefficients (A,B,C), as applicable, for Certification testing.

The results obtained by the use of this procedure may be analytically adjusted, as required, using good engineering judgment, and based upon relevant product/component attributes to support demonstration of compliance with CFR 40, Part 86 and Environmental Protection Agency (EPA) Advisory Circular 55C Dated 5.12.1986.

Proposed revisions to this procedure must be submitted per FAP03-179.

## 2.0 INSTRUMENTATION

Equivalent instrumentation may be used if approved by test responsible management before the test is run.

2.1 Fifth Wheel Assembly or non contact radar unit. The vehicle speed versus time instrumentation shall have an accuracy of at least 0.32 km/hr (0.20 mi/hr) and a resolution of 0.2 km/hr (0.1 mi/hr). The timing error shall be less than 0.1%. The speed device mounted on the rear of the vehicle must not interfere with the vehicle aerodynamics.

2.2 Data Acquisition System with a minimum parallel sampling rate of 5 samples per second per channel and a sample time accuracy of 1 msec. Anemometer Based Coastdown and Drive Method (ABCD Analysis Software).

**Note: The vehicle speed, relative airspeed, and yaw angle signals are to be filtered with identical low-pass filters that produce a minimum 60 dB/decade attenuation above a minimum corner frequency of 0.7 Hz and provide a minimum 20 dB attenuation at a frequency equal to one-half the data sampling rate.**

2.3 Weight scale, capable of measuring up to 4500 ± 5 kg (10,000 ± 10 lbs),

2.4 Weather Data

2.4.1 Relative Air Speed shall be recorded with a resolution of 0.04 kph (0.03 mph).

2.4.2 Yaw Angle shall be recorded with a resolution of 0.01 deg.

**Note: Relative wind speed and yaw angle is measured with a vehicle mounted anemometer. The anemometer may be mounted on a boom located in front of the vehicle, or mounted on the roof, 12 inches behind the windshield molding.**

2.4.3 Thermometer, capable of measuring 38 °C (100 °F). The temperature instrument shall have an accuracy of ±1 °C (±2 °F) and be located within 1.6 km (1 mile) of the test track or road, preferably as close as possible. The temperature instrument should measure air temperature and hence be shielded from the sun or other radiant energy sources.

2.4.4 Aneroid barometer, capable of measuring 105 kPa (31 in-Hg). The pressure instrument shall have an accuracy of at least ±0.3 kPa (±0.2 in Hg) and the measured barometric pressure shall be station pressure, not corrected to sea level. It is preferable to have the instrumentation within 1.6 km (1 mile) of the test road or track.

2.5 Tire pressure gage, capable of measuring up to 550 ± 3 kPa (80 ± 0.5 psi.)

2.6 All test measurement equipment must be calibrated and maintained per FAP03-015, Control, Calibration, and Maintenance of Measurement and Test Equipment.

2.7 All applicable safety guidelines and procedures must be followed.

## 3.0 EQUIPMENT AND FACILITIES

3.1 Track or road surface that is straight, flat and level for a minimum road or track length of 2.4 to 3.2 km (1.5 to 2 miles). The road or test track surface shall be hard, smooth, dry, and obstacle free with minimal interference from other vehicles during data collection. The surface texture and composition should be similar to road surfaces commonly in use. Grade shall not exceed 0.5% and road crown should be minimal. The grade must be constant, ± 0.1%, throughout the test section.

**Note: The absence of intermittent wind barriers near the road or track surface is preferred, to reduce positional wind variations.**

## 4.0 SAMPLE PREPARATION

4.1 Receive vehicle and vehicle specifications from the appropriate requesting activity.

4.1.1 The tires used on the vehicle must be broken in for at least 3218 km (2000 miles) or using an equivalent laboratory aging technique. The break-in should be done at the requester recommended tire pressure and specified wheel alignment. The break-in should be done on the test vehicle, or on a similar vehicle. The vehicle tires must have at least 50% of the original tire tread depth remaining.

4.1.2 Inspection. Inspect the vehicle in accordance with CETP 00.00-R-606 , Vehicle Inspection Standards except for weighing and wheel reaction determinations which are performed per this procedure (Section 4.8).

4.1.3 Preliminary Tune-up. Check engine oil level, transmission oil level, coolant level, and power steering fluid level. Vehicle must have 2000 miles accumulated mileage obtained from track or customer usage.

4.1.4 Powertrain Break-in. Any powertrain component must have at least 3218 km (2000 miles) of break-in before the test.

4.2 Install test tires.

4.3 Perform wheel alignment. Optional, may be waived if wheel alignment was set during preview testing. Check wheel alignment prior to test to ensure it is within requester specifications as outlined in the vehicle specifications (ensure that alignment is performed at the proper vehicle design curb weight). If wheel alignment is out of specification, adjust to the mean level and record data.

4.4 Ensure vehicle exterior is clean.

4.5 Install the following vehicle test instrumentation:

4.5.1 Mount vehicle speed sensor on rear license plate bracket.

4.5.2 Option 1: Install anemometer on the 8' boom on the front of vehicle's underbody. Ensure that the aerodynamic flow of the vehicle underbody is undisturbed. Set the anemometer height at the geometric center of the vehicle.

Option2: Install roof mounting baseplate with bracket stem located on the roof centerline 12" behind the windshield molding. The anemometer must be horizontal to the ground.

4.5.3 Place the data acquisition system inside the vehicle on the passenger seat and secure with the seat belt. Connect the speed sensor and anemometer wiring to the system. Connect the system to 12 volts DC to ensure proper operation.

**NOTE: Instrumentation wires and tape must be kept out of the air stream as much as possible.**

4.6 Adjust tires to a minimum of 34 kPa (5 psi) over the specified pressure, and soak the tires for a minimum of four hours at the test ambient temperature shielded from the sun or other radiant energy sources.

4.7 Adjust tire pressure to the "minimum recommended" values as specified in the vehicle sign-off sheets after tire soak.

4.8 Adjust the vehicle weight such that the weight of the test vehicle, including instrumentation, sufficient fuel to complete the test, and any on-board observing personnel, but excluding the driver, is within ± 45 kg. (100 lbs) of vehicle design curb weight (at 40% fuel tank fill) defined in the vehicle specifications. In addition, drive axle load must be within ± 23 kg (50 lbs) of the design drive axle load of the vehicle. Record weights.

**NOTE: All weighing must be done with all four tires on the same plane.**

4.9 Record vehicle suspension heights and attitude.

4.10 Requestor must indicate if the test vehicle has special software required to achieve "true neutral" specific for the coastdown test only. This feature may require special procedural steps to engage entry into the mode. All test vehicles must have PCM and TCM filenames recorded prior to the test by recording from the OBDII slot using a CARDAQ or similar system.

4.11 Ensure that the transfer case on 4 x 4 vehicles is shifted into two-wheel drive and front hubs are set in the "unlock" position.

4.12 Forward a copy of the vehicle specifications including all vehicle sign-off records to the Coastdown/FTTP/Special Programs Section, VEE -CED. Forward a copy of the appropriate new PAU vehicle sign-off sheets to the Certification Engineering Department for approval.

## 5.0 OPERATION

5.1 Operating conditions.

5.1.1 Wind Speed. Steady winds must be less than 32km/hr (20 mi/hr) and peak wind speed shall not exceed 48 km/hr(30 mi/hr). The data analysis corrects for wind speed in the direction traveled and crosswinds.

5.1.2 Temperature. The ambient temperature at the test time shall be in the range 10 – 30 °C (50 - 90 °F).

5.1.3 Barometric Pressure. The barometric pressure shall be in the range 104 kPa (31.0 in Hg) to 91 kPa (27.0 in Hg).

5.2 Record a 180° swing of the anemometer on the E-Prom of the data acquisition system.

5.3 Vehicle warm up.

5.3.1 Turn on vehicle instrumentation.

5.3.2 Conduct a 30 minute warm-up at a steady speed of 50 mph (80.5 km/hr) if on an oval test track. If on a straightaway, the warm up consists of 30 minutes on the straightaway at a steady speed of 50 mph (80.5 km/hr), after a moderate acceleration from the turn around at each end of the straightway.

**NOTE: A maximum five minute engine idling period is allowed between warm-up and coastdown runs. Record pre-run data.**

5.4 After warm-up, close all vehicle windows and vents. Check all instrumentation for proper operation. Turn off heating/air conditioning/ventilating system.

5.5 Record the following data during coastdowns.

5.5.1 Relative air speed and yaw angle - once per second.

5.5.2 Ambient dry bulb and wet bulb temperature – middle of test

5.5.3 Barometric pressure – middle of test

5.5.4 Relative humidity- middle of test

**NOTE: The standard speed for adjusting the dynamometer power absorber has been chosen as 50 mph (80.5 km/hr). The speed-time coastdown data must include this speed if it can be attained by the vehicle.**

5.6 Accelerate the vehicle to 75 mph (120.7 km/hr) and allow to stabilize for several seconds. Shift the transmission into neutral and start recording data. Collect the speed versus time data for the freely decelerating vehicle. Collect data from 70 - 10 mph (112.6 - 16.1 kph) speed range. For manual transmission vehicles, the clutch pedal must be released after the shift to neutral. The driver's foot must remain off the clutch, brake and accelerator pedals during the coastdown. Coastdown until the vehicle decelerates to 9 mph (14.5 km/hr) ensuring that the data is recorded. Stop recording data.

**NOTE: The coastdowns are conducted from 70 - 10 mph (112.6 - 16.1 kph). Analysis of the 70 -10 mph data will be used to determine $f_0$, $f_1$ and $f_2$ coefficients for 48" single-roll testing. Analysis of 60 - 20 mph data will be used to determine f 0 and $f_2$ used to calculate the 55 - 45 mph coastdown time for twin-roll testing. The 60 - 20 mph data is to be used for certification testing on the twin roll hydrokinetic dynamometer, while the 70 - 10 mph data will be used for certification testing on the single 48" roll electric dynamometer.**

5.7 Repeat the coastdown process, in alternated directions, for a minimum of 10 sequential runs, 5 sets of paired runs. (Use all valid paired data recorded.)

**NOTE: Drive additional paired runs immediately if on site observation indicates invalid test runs, such as application of brakes during coast down or high wind conditions. All invalid test runs must be retained with the test records along with the reason for the void.**

5.8 Weigh and record the weight of the vehicle including the driver, the test instrumentation, any ballast and any observers carried at the time of the coastdown testing immediately after completion of the coastdown tests.

5.9 Record the total and drive axle weights of the vehicle.

**NOTE: This total vehicle weight (gravitational mass) measurement represents a part of the total effective test mass of the vehicle as described in paragraph 6.2.**

5.10 Split Run and Coastdown Tests (conduct ONLY if straightaway length is insufficient)

5.10.1 Conduct practice runs to establish a break speed that provides a 10 mph (16.1 km/hr) overlap for two passes. Ensure that data is obtained down to 9 mph (14.5 km/hr).

5.10.2 Proceed to either runway and accelerate vehicle to 75 mph (120.7 km/hr) allowing several seconds to stabilize during the turn. Start recording data, shift the transmission into neutral while entering the straight-away. Collect the speed versus time data for the freely decelerating vehicle. For manual transmission vehicles the clutch pedal must be released after the shift to neutral. The driver's foot must remain off the clutch, brake and accelerator pedals during the coastdown. Coastdown until the vehicle decelerates to the break speed. Stop recording data.

5.10.3 Repeat paragraph 5.10.2 on the same runway in the opposite direction.

5.10.4 Proceed on the same runway in the opposite direction. Accelerate the vehicle to a speed 15 mph (24.1km/hr) higher than the brake speed during the turn. Start recording data. Shift the transmission to neutral while enter the straightway. Collect the speed versus time data for the freely decelerating vehicle. For manual transmission vehicles the clutch pedal must be released after the shift into neutral. The driver's foot must remain off the clutch, brake and accelerator pedals during the coastdown. Coast down until the vehicle decelerates to 9 mph (14.5 km/hr). Stop recording data.

5.10.5 Repeat paragraph 5.10.4 on the same runway in the opposite direction.

5.10.6 Repeat paragraph 5.10.2 through 5.10.5 until a total of at least 10 complete sequential runs have been completed (5 pairs).

5.11 Weigh and record the weight of the vehicle including the driver, the test instrumentation, any ballast and any observers carried at the time of the coastdown testing immediately after completion of the coastdown tests.

5.12 Record the total and drive axle weights of the vehicle.

## 6.0 GENERAL INSTRUCTIONS

6.1 Standard Ambient Conditions. Since the ambient conditions will affect the vehicle road load, test ambient conditions must be corrected to standard ambient conditions for consistent results. The standard ambient conditions are:

- Wind . . . . . . . . . . Still air, zero wind speed
- Temperature . . . . . . 68 °F (20 °C)
- Barometric Pressure . . 29.0 in Hg at 60 °F (98 kPa at 15.5 °C)

6.2 **Total Effective Test Mass Calculations.** The total vehicle inertia is represented by the total effective test mass of the vehicle which is defined as the sum of the gravitational mass of the vehicle [as measured per paragraph 5.8] and the effective equivalent mass of the rotating components of the vehicle as described below:

The equivalent effective mass of the vehicle rotating assemblies must be determined. If the rotational inertia is experimentally measured or calculated from the rotational inertias of the components, the equivalent effective mass of the assembly is given by:

$$Me = I/(RR)^2 \qquad (1)$$

$$Me = Mr + Mf$$

Where:

$$Mr = \frac{(IDS + IPI)(AR)^2 + IAA + 2I_{DB} + 2I(T/W)}{(RR)^2}$$

$$Mf = \frac{2\,I(T/W) + 2\,I_{NB}}{(RR)2}$$

and

AR = the axle ratio

Me = the equivalent effective mass of the assembly

Mf = the equivalent effective mass of the non-driven wheels

Mr = the equivalent effective mass of the driven wheels

I = the rotational inertia of the:

AA, axle assembly (ring gear axle, differential)

DB, driven wheel brake

DS, drive shaft

NB, non-driven wheel brake

PI, pinion

T/W, tire-wheel assembly

RR = the rolling radius of the tire (ft.)

The total effective test mass of the vehicle is then given by:

$$M = Mg + Me \qquad (2)$$

Where:

M = the total effective test mass of the vehicle

Mg = the gravitational mass of the vehicle as tested (measured in paragraph 5.11)

Me = the effective equivalent mass of the rotating components of the vehicle

Alternatively, if the rotational inertia of the tire wheel assemblies is not known, the effective mass of the four wheel-tire assemblies and drive train components may be estimated as 3.0 percent of the vehicle test mass. In this case, the total effective mass of the vehicle system is:

$$M = 1.030Mg \qquad (3)$$

6.3 **Road Force Data Reduction**.

6.3.1 The vehicle road load process supports methodology that EPA has approved to support electric dynamometer based certification efforts. The first step involves the fit of the measured data to the expected form of the more general road load model that EPA endorses for use in the determination of the aerodynamic and mechanical drag characteristics of the vehicle under the ambient pressure and temperature conditions in the test and under wind-free conditions. In the second step, the aerodynamic and mechanical characteristics analyzed in the first step are utilized in the prediction of the speed versus time history that would have been measured had the vehicle been coasted under the test ambient pressure and temperature and in a wind-free environment. In the third step the "data" predicted in the second step are analyzed with the current EPA road load model to determine the road load and chassis dynamometer coastdown time that must be achieved in order to duplicate the EPA-modeled road load on the dynamometer. The described process is totally implemented within one of the analysis options provided by the Anemometer Based Coastdown and Drive Method (ABCD Analysis Software).

6.3.2 The equation of motion that is utilized in the first step of the analysis process can be written as,

$M(dV/dt) = D_{MECH} + D_{AERO} + D_{GRAV}$ (1)

where:

$D_{MECH}$ - the mechanical drag force acting on the vehicle which is the sum of the tire rolling resistance and the losses due to friction inboard of the hubs at the front and rear axles.

$D_{AERO}$ - the aerodynamic drag acting on the vehicle

$D_{GRAV}$ - the drag due to gravitational effects - W(dh/ds)

h - local elevation of test course

s - distance traveled along test course

M - the total effective test mass of the vehicle

W - the gravitational weight of the test vehicle

V - vehicle speed

t - time

The mechanical and aerodynamic drag forces appearing in Equation (1) are modeled in the following manner:

$D_{MECH} = F_0 + F_1V + F_2V^2$

$D_{AERO} = 1/2\rho C_d(\Psi)A_fV_r^2$ where $C_d(\Psi)=\Sigma\alpha_i\Psi^i$ for i = 0 to 4

where:

$F_0$,$F_1$, and $F_2$ - coefficients in mechanical drag model

$\Psi$ = yaw angle

$A_f$ = aerodynamic drag reference area

$C_d(\Psi)$ = vehicle drag coefficient at yaw angle $\Psi$

$\rho$ = air density

$V_r$ = relative airspeed

$\alpha_i$ = coefficients in drag coefficient variation with yaw angle model

Combining the various terms identified above with Equation (1), the final form of the equation of motion utilized in the first step of the analysis process becomes,

$M(dV/dt) = F_0 + F_1V + F_2V^2 + 1/2\rho A_f\Sigma\alpha_i(\psi^i V_r^2) + W(dh/ds)|_s$ (2)

for i from 0 to 4

6.3.3 The implementation of the gravitational drag model in Equation (2) requires that the elevation profile of the test track be known. In situations where the grades do not exceed the limitations imposed by the current EPA procedure and the analysis utilizes data measured in pairs of coasts run in opposite directions, the analysis can be carried out as though the track surface had a constant elevation.

6.3.4 The fundamental data utilized in the solution for the three mechanical drag coefficients $F_0$, $F_1$ and $F_2$ and the five aerodynamic drag coefficients $\alpha_i$ are the time histories of the vehicle speed, the relative air speed, and the yaw angle experienced by the vehicle during the test. These histories are recorded in the form of sets of parallel observations which are simultaneously sampled at equal time intervals during the period of each coastdown test.

Integrating Equation (2) over a single such time interval and rearranging obtains,

$$M(\Delta V/\Delta t) = F_0 + \overline{F_1 V} + \overline{F_2 V^2} + 1/2\rho A_f \overline{\Sigma\alpha_i(\psi^i V_r^2)} + \overline{W(dh/db)}|_s \qquad (3)$$

where the overbars represent averages of the respective quantities over time interval $\Delta t$.

Utilizing the recorded V, $V_r$ and the $\Psi$ data together with the other independently obtained quantities in the evaluation of Equation (3) for each time interval over which data are recorded, approximately 1200 equations are obtained in terms of the three unknown valves of $F_0$, $F_1$ and $F_2$ and the five unknown values of $\alpha_i$. The solution for these values is obtained using linear regression.

6.3.5 The second step in the solution process involves the prediction of the speed versus time history that would have been measured had the test vehicle been coasted on a level track in the absence of winds. In such a case, the grade would be zero, the relative airspeed would be equal the vehicle speed, and the yaw angle would be zero. The prediction is obtained from an integration of Equation (2) wherein the required values for $F_0$, $F_1$ and $F_2$ and a0 are provided by the solution obtained in the first step of the analysis process. Although this integration can be obtained by analytic methods, a numerical integration is used within ABCD. Noting that $\alpha_0$ = the zero yaw drag coefficient - $C_d$, the sought after speed versus time prediction is obtained by numerically integrating the following expression,

$$V(t) = V_0 - \int F_0 + F_1 V + (F_2 + 1/2\rho A_f C_d)V^2)dt \qquad (4)$$

where V0 is the initial speed and V(t) represents the predicted speed versus time history for coast on a level track in absence of winds. In view of its intended use as described below, the predicted speed is output as "data" at one second intervals over a 60 to 20 mph or 70 to 10 mph speed range.

6.3.6 The coefficients F0, F1 and F2 (adjusted per section 6.4 below) are used as force targets in subsequent dyno force derivations.

6.4 Ambient Correction to the Total Road Force

6.4.1 The total road force must be corrected to the standard ambient conditions. Since the $F_2$ coefficient is assumed to be the aerodynamic drag component, this term is corrected for differences between the air density at the test conditions and the air density at the standard conditions. The corrections can be written in the form:

$$F_2' = C^T C^B F_2 \quad (7)$$

Where:

$F_2'$ = the corrected force coefficient for the $v^2$ term

$C^T$ = the temperature correction factor for the ambient conditions

$C^B$ = the barometric correction factor for the ambient conditions

The temperature correction factor is:

$$C^T = (459.7° + T)/527.7 °F \quad (8)$$

Where:

T = the test ambient temperature in degrees F.

The barometric pressure correction factor is:

$$C^B = 29.0 \text{ in Hg/BAR} \quad (9)$$

Where:

BAR = the test ambient barometric pressure in inches Hg.

6.4.2 The terms $F_0$ and $F_1$ are assumed to represent the mechanical losses and should be corrected for the difference between the test ambient temperature and the standard ambient temperature. The correction may be expressed as:

$$F_{0'} = F_0 [1 + K_0(T - 68°F)] \text{ and } F_{1'} = F_1 [1 + K_0(T - 68°F)] \quad (10)$$

Where $K_0$ may be based on empirical data for the particular vehicle drive train and tires tested, if this information is available, or may be assumed to be 4.5 x 10 -3 /°F.

6.4.3 The force on the vehicle at the standard ambient condition is, therefore, given from the above terms as:

$$F' = F_0' + F_1'V + F_2'V^2 \quad (11)$$

## 7.0 PRESENTATION OF DATA

7.1 The final test report should contain at least the force coefficients and the vehicle mass.

## 8.0 REFERENCES

8.1 Environmental Protection Agency (EPA) Advisory Circular 55C Dated 5.12.1986.

8.2 CETP 00.00-R-606, Vehicle Inspection Standards.

8.3 ESA08P-223B, Accelerated Durability Vehicle Mileage Accumulation Cycle.

8.4 FAP03-015, Control, Calibration, and Maintenance of Measurement and Test Equipment.

8.5 FAP03-179, Developing Corporate Engineering Test Procedures.

## 9.0 RECORD OF REVISIONS

See metadata field "Review Note".

## 10.0 ATTACHMENT

None.

# 2013 MY Truck
# Fuel Tank Information

NOTE: Nominal Fuel Tank Capacity = Useable Refill Capacity

| MODEL TYPE | AVAIL-ABILITY (S=Standard O=Optional) | TANK CODE | NOMINAL FUEL TANK CAPACITY Liters | NOMINAL FUEL TANK CAPACITY US Gallons | USEABLE 40% FILL US Gallons | VAPOR VOLUME CUBIC FT @ 40% FILL | TANK MATERIAL |
|---|---|---|---|---|---|---|---|
| **Escape** | S | C5 | 57.0 | 15.1 | 6.0 | 1.62 | HDPE Plastic |
| **Explorer** | S | FF | 70.4 | 18.6 | 7.4 | 2.07 | HDPE Plastic |
| **Transit Connect** | S | VN | 58.3 | 15.4 | 6.2 | 1.5 | HDPE Plastic |
| **F-150 3.5L GTDI (4x2) ONLY** | | | | | | | |
| 144.5", 156.5", 163.0" | S | FG | 98.4 | 26.0 | 10.4 | 3.56 | HDPE Plastic |
| **F-150 3.5L GTDI (4x4) ONLY** | | | | | | | |
| 144.5", 156.5", 163.0" | S | FH | 136.3 | 36.0 | 14.4 | 3.36 | HDPE Plastic |
| **F-150 All Engines Except 3.5L GTDI** | | | | | | | |
| **Regular Cab (4x4/4x2)** | | | | | | | |
| 126.0" | S | FA | 98.4 | 26.0 | 10.4 | 2.60 | HDPE Plastic |
| 144.5" | S | FC | 98.4 | 26.0 | 10.4 | 3.56 | HDPE Plastic |
| | O | FD(1) | 136.3 | 36.0 | 14.4 | 3.36 | HDPE Plastic |
| (1) Optional in lieu of Standard Tank. Req. with 8200# GVW 4x4. | | | | | | | |
| **Super Cab (4x4/4x2) All Engines Except 3.5L GTDI** | | | | | | | |
| 132.5" (4x4 SVT Only) | S | FA | 98.4 | 26.0 | 10.4 | 2.60 | HDPE Plastic |
| 144.5" (4x2 ONLY) | S | FC | 98.4 | 26.0 | 10.4 | 3.56 | HDPE Plastic |
| | O | FD(1) | 136.3 | 36.0 | 14.4 | 3.36 | HDPE Plastic |
| 163.0" (4x2 ONLY) | S | FC | 98.4 | 26.0 | 10.4 | 3.56 | HDPE Plastic |
| | O | FD(1) | 136.3 | 36.0 | 14.4 | 3.36 | HDPE Plastic |
| (1) Optional in lieu of Standard Tank. Req. with 4x4. | | | | | | | |
| **Super Crew Cab (4x4/4x2) All Engines Except 3.5L GTDI** | | | | | | | |
| 144.5" (4x2 ONLY) | S | FC | 98.4 | 26.0 | 10.4 | 3.56 | HDPE Plastic |
| | O | FD(1) | 136.3 | 36.0 | 14.4 | 3.36 | HDPE Plastic |
| 144.5" (4x4 SVT ONLY) | S | FD | 136.3 | 36.0 | 14.4 | 3.36 | HDPE Plastic |
| 156.5" (4x2 ONLY) | S | FC | 98.4 | 26.0 | 10.4 | 3.56 | HDPE Plastic |
| | O | FD(1) | 136.3 | 36.0 | 14.4 | 3.36 | HDPE Plastic |
| (1) Optional in lieu of Standard Tank. Req. with 4x4. | | | | | | | |
| **Expedition** | | | | | | | |
| 4x2 | S | TJ | 106.0 | 28.0 | 11.2 | 2.7 | HDPE Plastic |
| 4x4 | S | TJ | 106.0 | 28.0 | 11.2 | 2.7 | HDPE Plastic |
| **Expedition EL** | | | | | | | |
| 4x2 | S | TE | 126.8 | 33.5 | 13.4 | 3.3 | HDPE Plastic |
| 4x4 | S | TE | 126.8 | 33.5 | 13.4 | 3.3 | HDPE Plastic |
| **Navigator** | | | | | | | |
| 4X2 | S | TJ | 106.0 | 28.0 | 11.2 | 2.7 | HDPE Plastic |
| 4x4 | S | TJ | 106.0 | 28.0 | 11.2 | 2.7 | HDPE Plastic |
| **Navigator L** | | | | | | | |
| 4X2 | S | TE | 126.8 | 33.5 | 13.4 | 3.3 | HDPE Plastic |
| 4x4 | S | TE | 126.8 | 33.5 | 13.4 | 3.3 | HDPE Plastic |

# 2013 MY Truck
# Fuel Tank Information

NOTE: Nominal Fuel Tank Capacity = Useable Refill Capacity

| MODEL TYPE | AVAIL-ABILITY (S=Standard O=Optional) | TANK CODE | NOMINAL FUEL TANK CAPACITY Liters | NOMINAL FUEL TANK CAPACITY US Gallons | USEABLE 40% FILL US Gallons | VAPOR VOLUME CUBIC FT @ 40% FILL | TANK MATERIAL |
|---|---|---|---|---|---|---|---|
| **E-150 Regular Van** | S | TR | 125.7 | 33.2 | 13.3 | 3.26 | HDPE Plastic |
| **E-150 Regular Wagon** | S | TR | 125.7 | 33.2 | 13.3 | 3.26 | HDPE Plastic |
| **E-250 Regular/Super Van/Cutaway** | S | TR | 125.7 | 33.2 | 13.3 | 3.26 | HDPE Plastic |
| **E-350 Regular/Super Van** | S | TR | 125.7 | 33.2 | 13.3 | 3.26 | HDPE Plastic |
| **E-350 Regular/Super Wagon** | S | TR | 125.7 | 33.2 | 13.3 | 3.26 | HDPE Plastic |
| **E-350 Super Duty Stripped Chassis** | | | | | | | |
| 138" , 158" & 176" | S | TH | 151.4 | 40.0 | 16.0 | 3.85 | Steel |
| 158" (N/A w/ 10,000 GVWR) | O | TM | 208.2 | 55.0 | 22.0 | 5.63 | Steel |
| **E-350 Super Duty Cutaway** | | | | | | | |
| 138" Wide Frame | S | TR | 125.7 | 33.2 | 13.3 | 3.26 | HDPE Plastic |
| 138", 158" & 176" | S | TH | 151.4 | 40.0 | 16.0 | 3.85 | Steel |
| 158" (N/A w/ 10,000 GVWR) | O | TM | 208.2 | 55.0 | 22.0 | 5.63 | Steel |
| **E-450 Super Duty Stripped Chassis** | | | | | | | |
| 158" & 176" | O | TH | 151.4 | 40.0 | 16.0 | 3.85 | Steel |
| 158" & 176" | S | TM | 208.2 | 55.0 | 22.0 | 5.63 | Steel |
| **E-450 Super Duty Cutaway** | | | | | | | |
| 158" & 176" | O | TH | 151.4 | 40.0 | 16.0 | 3.85 | Steel |
| 158" & 176" | S | TM | 208.2 | 55.0 | 22.0 | 5.63 | Steel |
| **Wide Frame Pickups (4X2 & 4X4)** | | | | | | | |
| **Long Pickup Box** | | | | | | | |
| **(Includes Pickup Box Deletes)** | | | | | | | |
| **F-250 / F-350 / F450** | | | | | | | |
| Reg Cab 137" | S | TW | 132.5 | 35.0 | 14.0 | 3.260 | HDPE Plastic |
| Reg Cab 137" DIESEL ONLY | S | TY | 98.4 | 26.0 | 10.4 | 2.286 | HDPE Plastic |
| Super Cab 158" | S | TW | 132.5 | 35.0 | 14.0 | 3.260 | HDPE Plastic |
| Super Cab 158" DIESEL ONLY | S | TS | 142.0 | 37.5 | 15.0 | 3.342 | HDPE Plastic |
| Crew Cab 172.4" | S | TW | 132.5 | 35.0 | 14.0 | 3.260 | HDPE Plastic |
| Crew Cab 172.4" DIESEL ONLY | S | TS | 142.0 | 37.5 | 15.0 | 3.342 | HDPE Plastic |
| **Short Pickup Box** | | | | | | | |
| **(Includes Pickup Box Deletes)** | | | | | | | |
| **F-250 / F-350** | | | | | | | |
| Super Cab 141.8" | S | TW | 132.5 | 35.0 | 14.0 | 3.260 | HDPE Plastic |
| Super Cab 141.8" DIESEL ONLY | S | TY | 98.4 | 26.0 | 10.4 | 2.286 | HDPE Plastic |
| Crew Cab 156.2" | S | TW | 132.5 | 35.0 | 14.0 | 3.260 | HDPE Plastic |
| Crew Cab 156.2" DIESEL ONLY | S | TY | 98.4 | 26.0 | 10.4 | 2.286 | HDPE Plastic |
| **Narrow Frame Chassis Cabs (4X2 & 4X4, Gas and Diesel)** | | | | | | | |
| **F-350** | | | | | | | |
| Reg Cab 141" | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY**(2)** | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST**(3)** | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| Reg Cab 165" DRW only | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY**(2)** | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST**(3)** | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| Super Cab 162" | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |

# 2013 MY Truck
# Fuel Tank Information

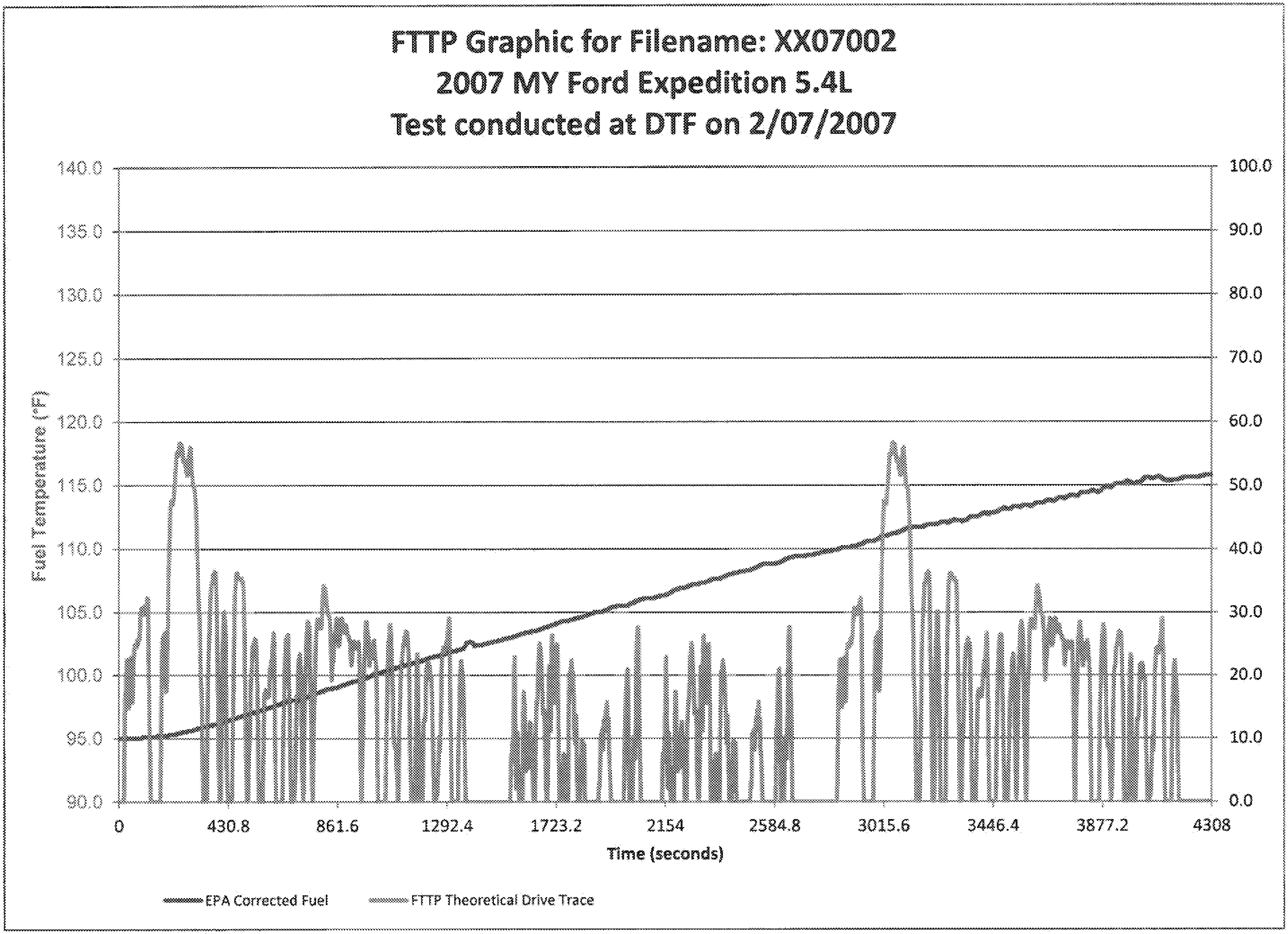
NOTE: Nominal Fuel Tank Capacity = Useable Refill Capacity

| MODEL TYPE | AVAIL-ABILITY (S=Standard O=Optional) | TANK CODE | NOMINAL FUEL TANK CAPACITY Liters | NOMINAL FUEL TANK CAPACITY US Gallons | USEABLE 40% FILL US Gallons | VAPOR VOLUME CUBIC FT @ 40% FILL | TANK MATERIAL |
|---|---|---|---|---|---|---|---|
| | O | SY(2) | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST(3) | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| Crew Cab 176" | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY(2) | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST(3) | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| (2) Optional in lieu of Standard w/DRW. | | | | | | | |
| (3) Dual Tanks (SW + SY) - Diesel DRW Only. | | | | | | | |
| **F-450 / F-550** | | | | | | | |
| Reg Cab 141" | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY(2) | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST(3) | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| Reg Cab 165" DRW only | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY(2) | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST(3) | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| Reg Cab 189" | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY(4) | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST(3) | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| Reg. Cab 201" | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY(2) | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST(3) | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| Super Cab 162" | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY(2) | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST(3) | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| Crew Cab 176" | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY(2) | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST(3) | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| Crew Cab 200" | S | SW | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| | O | SY(4) | 106.0 | 28.0 | 11.2 | 2.710 | Steel |
| | O | ST(3) | 257.4 | 68.0 | 27.2 | 6.650 | Steel |
| (2) Optional in lieu of Standard w/DRW. | | | | | | | |
| (3) Dual Tanks (SW + SY) - Diesel DRW Only. | | | | | | | |
| (4) Diesel only. In lieu of Standard w/DRW. | | | | | | | |
| **F-53 Super Duty Class A Motor Home** | | | | | | | |
| Stripped Chassis | S | | 308.5 | 81.5 | 32.6 | 8.700 | Steel |
| **F-59 Step Van** | S | | 151.4 | 40.0 | 16.0 | 3.940 | Steel |
| **F-650** Reg. Cab / Super Cab | S | | 159.0 | 42.0 | 16.8 | 4.12 | Steel |
| Reg. Cab / Super Cab | O | | 227.1 | 60.0 | 24.0 | 5.63 | Steel |
| Crew Cab | S | | 227.1 | 60.0 | 24.0 | 5.63 | Steel |

# 2013 Passenger Car
# Fuel Tank Capacities

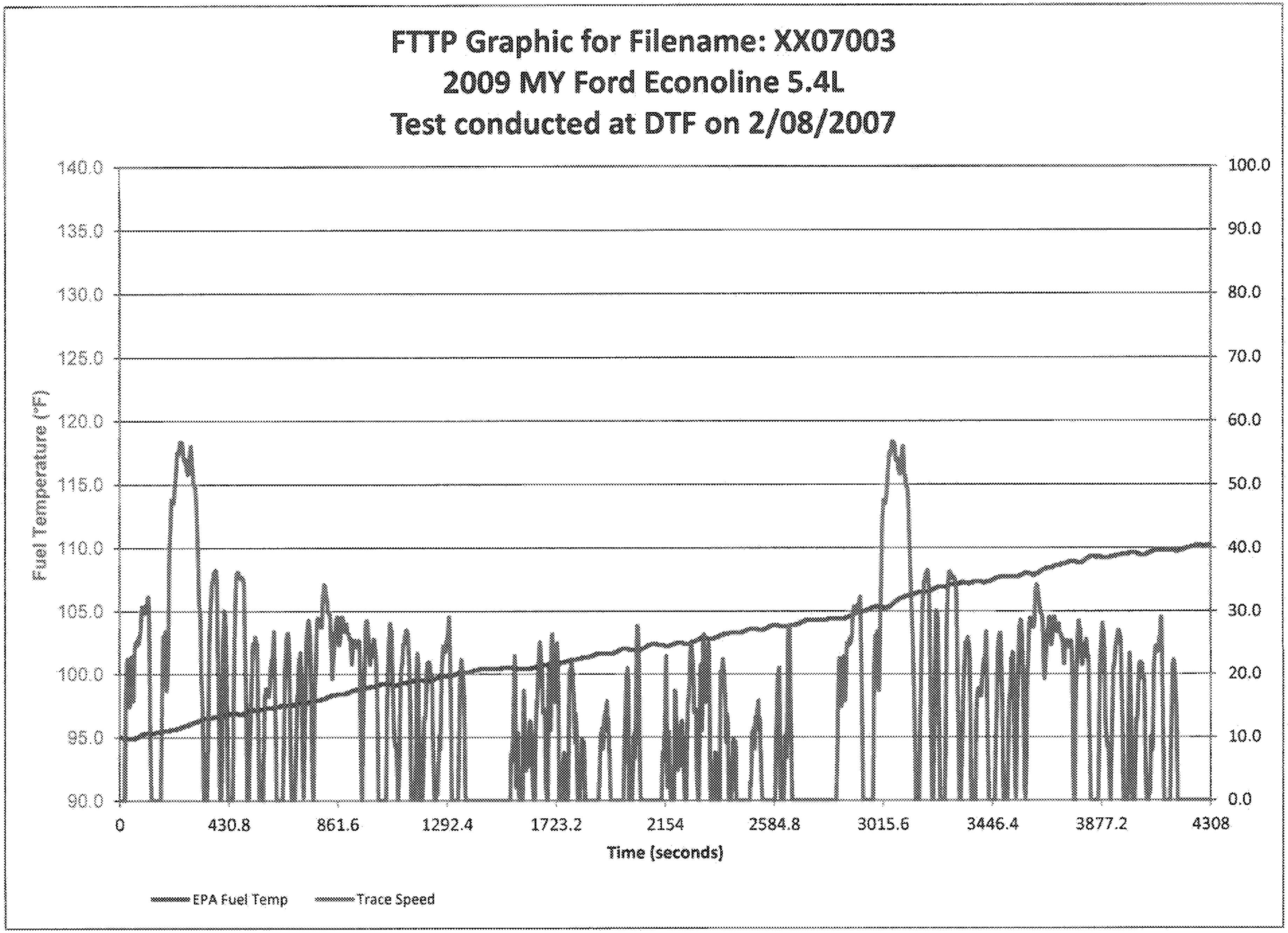
| Carline | Tank Code | Usable Capacity (gallons) | Usable 40% Fill (gallons) | Vapor Volume @ 40% Fill (cu.ft.) | Tank Material |
|---|---|---|---|---|---|
| **Fiesta (B299N)** | B | 12.4 | 5.0 | 1.4 | HDPE Plastic |
| **Focus (C346N)** | C | 12.4 | 5.0 | 1.6 | HDPE Plastic |
| **Fusion (CD391)/MKZ (CD533) 1.6L GTDI, 2.5L, 2.0L GTDI-FWD** | CF | 16.5 | 6.6 | 1.7 | HDPE Plastic |
| **Fusion (CD391)/MKZ (CD533) 2.0L-AWD, 3.7L (FWD/AWD)** | CA | 17.5 | 7.0 | 1.6 | HDPE Plastic |
| **Fusion (CD391)/MKZ (CD533) FHEV** | CH | 13.5 | 5.4 | 1.8 | HDPE Plastic |
| **C-Max (C344) FHEV** | CH | 13.5 | 5.4 | 1.4 | Steel |
| **Fusion (CD391)/C-Max (C344) Energi PHEV** | CP | 14.0 | 5.6 | 1.5 | Steel |
| **Taurus (D258)/MKS (D385)** | DF (FWD)<br>DA (AWD, All Police) | 19.0<br>19.0 | 7.6<br>7.6 | 2.4<br>2.1 | HDPE Plastic |
| **Edge (U387)/MKX (U388)** | EF (FWD)<br>EA (AWD) | 18.3<br>19.2 | 7.3<br>7.7 | 1.8 1.9 | HDPE Plastic<br>HDPE Plastic |
| **Flex (D471)/MKT (D472)** | FF | 18.6 | 7.4 | 2.1 | HDPE Plastic |
| **Mustang (S197)** | M | 16.0 | 6.4 | 1.5 | HDPE Plastic |

| FTTP Testing Information | | | | | | Product Coverage | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Profile | Ending Temperature | | Fuel | | Heat Shield Size | Engine Size (Liters) | Vehicle Model Name | Fuel Tank Sizes (Gallons) | System Type | Certification Test Group(s ) |
| Current | Fuel (F) | Vapor (F) | Tank Capacity (Gallons) | System Type | | | | | | |
| XX07002 | 115.8 | 132.9 | 28.0 | MRFS | Half | 5.4L 3V FFV | Expedition / Expedition EL / Navigator / Navigator L / Limo | 28 , 33.5 | MRFS | DFMXT05.44BC, DFMXT05.44HY, DFMXT05.45BR |
| XX07003 | 110.2 | 116.5 | 40.0 | MRFS | Half | 5.4L 2V FFV | Econoline Incomplete / Ambulance Package | 40, 55 | MRFS | DFMXE05.4AFD, DFMXE05.4BWC, DFMXE05.4AFF, DFMXE05.4BWL |
| XX07007 | 113.5 | 122.5 | 40.0 | MRFS | Half | 6.8L 2V | Econoline Incomplete / Ambulance Package | 40, 55 | MRFS | DFMXE06.8BWX, DFMXE06.8AFA |
| XX07008 | 115.8 | 122.3 | 26.0 | MRFS | Half | 3.7L/5.0L FFV | F-150 FFV | 26.0, 36.0 | MRFS | DFMXT03.73DP, DFMXT05.03D7 |
| XX07306 | 116.6 | 118.4 | 18.6 | MRFS | Half | 3.7L, 3.5L | MKZ, Taurus, Taurus Police, MKS, Flex, MKT, MKT Limo/Hearse, Explorer, Explorer Police | 19 | MRFS | DFMXV03.7VE8, DFMXV03.7VHJ, DFMXT03.73E8 |
| XX08025 | 121.1 | 132.5 | 19.0 | MRFS | Partial | 3.5L GTDI | Taurus MKS, Flex, MKT, U502 GTDI | 19 | MRFS | DFMXV03.5VEP |
| XX08034 | 115.4 | 112.8 | 14.8 | MRFS | Partial | | Mustang Shelby GT500 Manual, Transit | | | DFMXV05.8VE2, DFMXT02.01DW |
| XX08043 | 112.5 | 118.7 | 35.0 | MRFS | Partial | 6.2L FFV | F Series Superduty Complete / Box Delete | 35 | MRFS | DFMXT06.27HL |
| XX09001 | 112.1 | 100.1 | 16.0 | MRFS | Partial | 3.7L | Mustang | 16 | ERFS | DFMXV03.7VDT |
| XX09004 | 120.6 | 126.1 | 16.0 | MRFS | Full | 5.0L | Mustang GT Automatic | 16 | MRFS | DFMXV05.0VD5 |
| XX09007 | 117.1 | 131.2 | 35.0 | MRFS | Partial | 4.6L/ 5.4L FFV | Econoline Complete | 33.2 | MRFS | DFMXT05.45HL, DFMXT06.85HT, DFMXT04.65H9, DFMXT05.45HK |
| XX09008 | 115.5 | 107.9 | 28.9 | MRFS | Half | 6.2L FFV | F Series Superduty Incomplete | 28, 40 | MRFS | DFMXT06.27HL |
| XX09012 | 115.3 | 118.7 | 18.0 | MRFS | 3/4 | 3.5L, 3.7L | Edge, MKX | 18.1, 19.2 | MRFS | DFMXT03.72EE |
| XX09016 | 118.2 | 123.6 | 35.0 | MRFS | Half | 6.2L | F-150 Raptor | 36 | MRFS | DFMXT06.24D2 |
| XX09303 | 122.9 | 105.7 | 12.4 | MRFS | Partial | 1.6L | Fiesta | 12.4 | MRFS | DFMXV01.6VDB |
| XX10009 | 120.0 | 120.9 | 26.0 | MRFS | Partial | 3.5L | F-150 GTDI | 26 | MRFS | DFMXT03.54DX |
| XX10014 | 116.7 | 95.3 | 12.5 | SMRFS | Partial | 2.0L | Focus PZEV (non-FFV) | 12.4 | SMRFS | DFMXV02.0VZ2 |
| XX10015 | 113.3 | 115.0 | 19.0 | MRFS | Full | 3.5L | Taurus/Taurus Police - FFV/Explorer/ Explorer Police | 19 | MRFS | DFMXV03.5VEA, DFMXT03.73DM |
| XX11008 | 111.8 | 117.7 | 19.0 | ERFS | Partial | 2.0L GTDI | Edge | | ERFS / SMRFS - DI | DFMXT02.02EC |
| XX11009 | 111.3 | 102.3 | 14.6 | SMRFS | Full | 2.5L, 2.0L/1.6L GTDI | Fusion, Escape/Kuga | 14.6, 15.1 | SMRFS | DFMXV02.5VEX, DFMXT02.52ET, |
| XX11010 | 121.6 | 114.1 | 12.4 | SMRFS | Partial | 2.0L FFV | Focus FFV, Focus ST | 12.4 | SMRFS | DFMXV02.0VD2, DFMXV02.0VER |
| XX11301 | 113.2 | 110.9 | 42.0 | MRFS | | 6.8L | F Series Superduty | 42, 60 | MRFS | DFMXE06.8BW5 |


FTTP Graphic for Filename: XX07002
2007 MY Ford Expedition 5.4L
Test conducted at DTF on 2/07/2007
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace

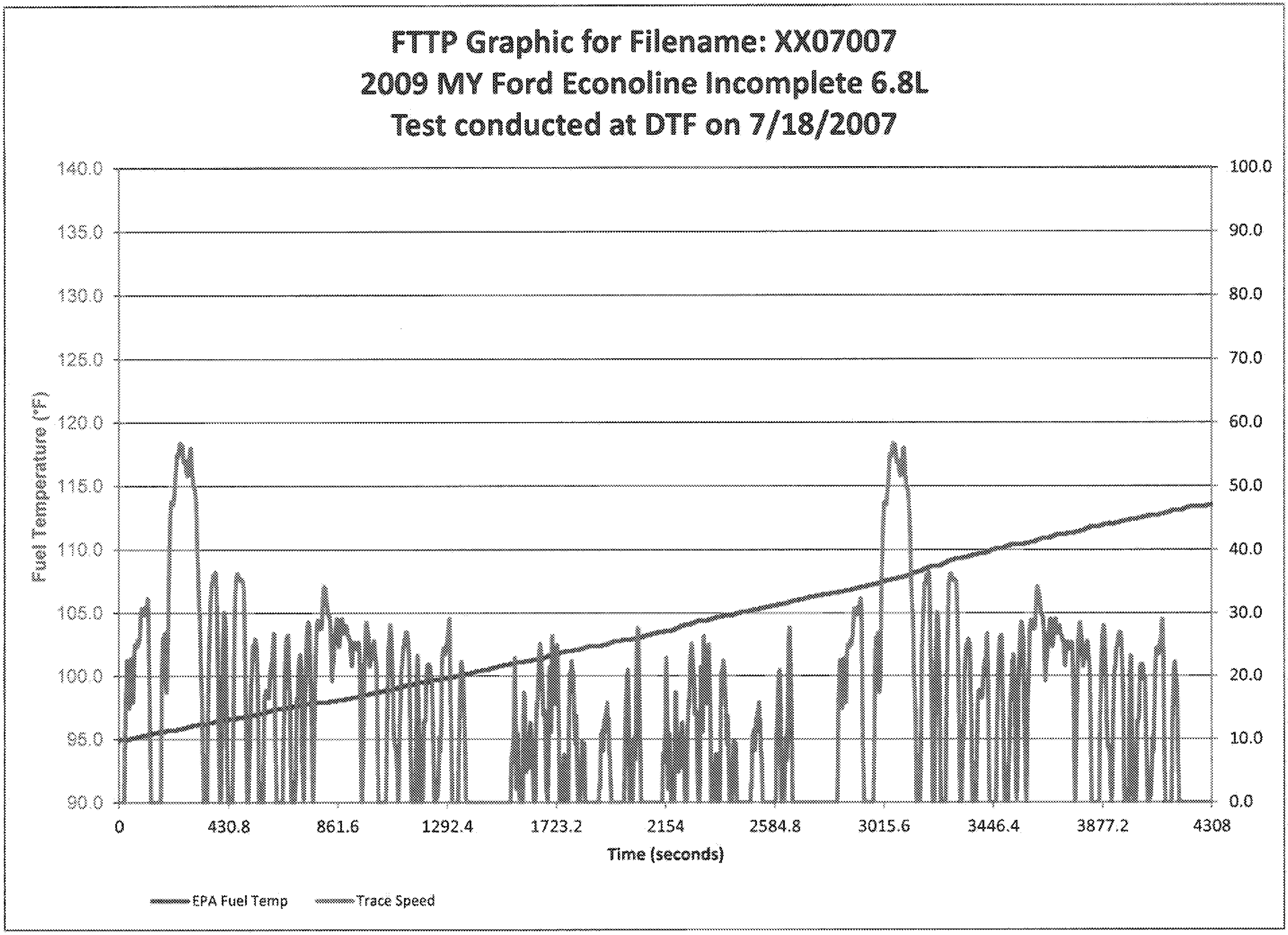
FTTP for Filename: XX07002
(used for DFMXT05.44BC, DFMXT05.44HY, DFMXT05.45BR)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.0 |
| 121 | 10.3 | 95.1 |
| 181 | 26.8 | 95.2 |
| 241 | 56.6 | 95.4 |
| 301 | 48.3 | 95.7 |
| 361 | 31.9 | 96.0 |
| 421 | 23.2 | 96.4 |
| 481 | 35.1 | 96.7 |
| 541 | 25.0 | 97.1 |
| 601 | 22.2 | 97.5 |
| 661 | 26.1 | 97.9 |
| 721 | 10.4 | 98.1 |
| 781 | 28.2 | 98.6 |
| 841 | 19.7 | 99.0 |
| 901 | 26.5 | 99.3 |
| 961 | 7.1 | 99.7 |
| 1021 | 2.5 | 100.2 |
| 1081 | 13.5 | 100.5 |
| 1141 | 25.0 | 100.9 |
| 1201 | 11.0 | 101.2 |
| 1261 | 7.2 | 101.5 |
| 1321 | 0.0 | 101.9 |
| 1381 | 0.0 | 102.6 |
| 1441 | 0.0 | 102.5 |
| 1501 | 0.0 | 102.8 |
| 1561 | 21.7 | 103.1 |
| 1621 | 12.1 | 103.4 |
| 1681 | 8.0 | 103.8 |
| 1741 | 0.0 | 104.2 |
| 1801 | 12.8 | 104.5 |
| 1861 | 0.0 | 104.9 |
| 1921 | 14.3 | 105.2 |
| 1981 | 0.0 | 105.5 |
| 2041 | 22.8 | 105.9 |
| 2101 | 0.0 | 106.1 |
| 2161 | 14.5 | 106.4 |
| 2221 | 12.3 | 106.9 |
| 2281 | 3.7 | 107.2 |
| 2341 | 0.0 | 107.6 |
| 2401 | 12.3 | 107.9 |
| 2461 | 0.0 | 108.2 |
| 2521 | 15.1 | 108.6 |
| 2581 | 0.0 | 108.8 |
| 2641 | 26.0 | 109.3 |
| 2701 | 0.0 | 109.4 |
| 2761 | 0.0 | 109.6 |
| 2821 | 0.0 | 109.9 |
| 2881 | 24.6 | 110.1 |
| 2941 | 0.0 | 110.5 |
| 3001 | 19.4 | 110.9 |
| 3061 | 55.9 | 111.2 |
| 3121 | 39.3 | 111.6 |
| 3181 | 34.6 | 111.8 |
| 3241 | 0.0 | 112.1 |
| 3301 | 34.7 | 112.2 |
| 3361 | 8.1 | 112.5 |
| 3421 | 26.3 | 112.7 |
| 3481 | 24.5 | 113.1 |
| 3541 | 5.0 | 113.3 |
| 3601 | 28.3 | 113.4 |
| 3661 | 25.5 | 113.8 |
| 3721 | 25.6 | 114.0 |
| 3781 | 22.5 | 114.2 |
| 3841 | 0.0 | 114.6 |
| 3901 | 8.7 | 114.9 |
| 3961 | 8.9 | 115.1 |
| 4021 | 14.8 | 115.2 |
| 4081 | 12.6 | 115.5 |
| 4141 | 0.0 | 115.4 |
| 4201 | 0.0 | 115.6 |
| 4261 | 0.0 | 115.7 |
| 4308 | 0.0 | 115.8 |


FTTP Graphic for Filename: XX07003
2009 MY Ford Econoline 5.4L
Test conducted at DTF on 2/08/2007
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Fuel Temperature (°F)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Fuel Temp
Trace Speed

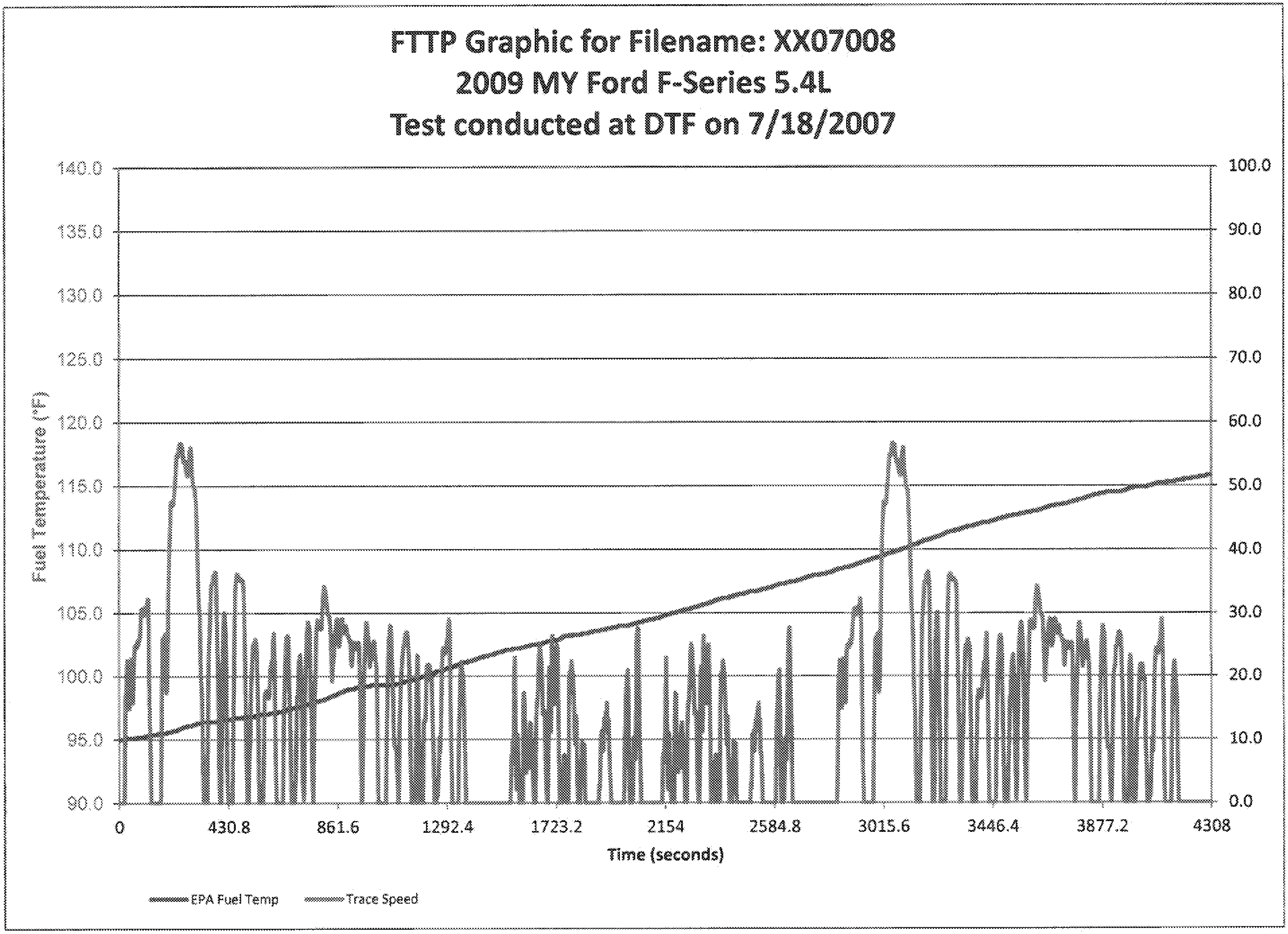
FTTP for Filename: XX07003
(used for DFMXE05.4AFD, DFMXE05.4BWC, DFMXE05.4AFF, DFMXE05.4BWL)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 94.9 |
| 121 | 10.3 | 95.3 |
| 181 | 26.8 | 95.5 |
| 241 | 56.6 | 95.7 |
| 301 | 48.3 | 96.2 |
| 361 | 31.9 | 96.5 |
| 421 | 23.2 | 96.8 |
| 481 | 35.1 | 96.8 |
| 541 | 25.0 | 97.1 |
| 601 | 22.2 | 97.3 |
| 661 | 26.1 | 97.5 |
| 721 | 10.4 | 97.7 |
| 781 | 28.2 | 97.9 |
| 841 | 19.7 | 98.3 |
| 901 | 26.5 | 98.5 |
| 961 | 7.1 | 98.9 |
| 1021 | 2.5 | 99.1 |
| 1081 | 13.5 | 99.1 |
| 1141 | 25.0 | 99.4 |
| 1201 | 11.0 | 99.5 |
| 1261 | 7.2 | 99.8 |
| 1321 | 0.0 | 99.9 |
| 1381 | 0.0 | 100.1 |
| 1441 | 0.0 | 100.4 |
| 1501 | 0.0 | 100.4 |
| 1561 | 21.7 | 100.5 |
| 1621 | 12.1 | 100.4 |
| 1681 | 8.0 | 100.7 |
| 1741 | 0.0 | 100.9 |
| 1801 | 12.8 | 101.1 |
| 1861 | 0.0 | 101.4 |
| 1921 | 14.3 | 101.6 |
| 1981 | 0.0 | 101.9 |
| 2041 | 22.8 | 101.9 |
| 2101 | 0.0 | 102.4 |
| 2161 | 14.5 | 102.2 |
| 2221 | 12.3 | 102.5 |
| 2281 | 3.7 | 102.7 |
| 2341 | 0.0 | 102.8 |
| 2401 | 12.3 | 103.2 |
| 2461 | 0.0 | 103.4 |
| 2521 | 15.1 | 103.6 |
| 2581 | 0.0 | 103.9 |
| 2641 | 26.0 | 103.8 |
| 2701 | 0.0 | 104.2 |
| 2761 | 0.0 | 104.3 |
| 2821 | 0.0 | 104.4 |
| 2881 | 24.6 | 104.6 |
| 2941 | 0.0 | 105.0 |
| 3001 | 19.4 | 105.3 |
| 3061 | 55.9 | 105.7 |
| 3121 | 39.3 | 106.3 |
| 3181 | 34.6 | 106.5 |
| 3241 | 0.0 | 106.9 |
| 3301 | 34.7 | 107.1 |
| 3361 | 8.1 | 107.2 |
| 3421 | 26.3 | 107.3 |
| 3481 | 24.5 | 107.7 |
| 3541 | 5.0 | 107.7 |
| 3601 | 28.3 | 107.9 |
| 3661 | 25.5 | 108.4 |
| 3721 | 25.6 | 108.7 |
| 3781 | 22.5 | 108.8 |
| 3841 | 0.0 | 109.3 |
| 3901 | 8.7 | 109.2 |
| 3961 | 8.9 | 109.5 |
| 4021 | 14.8 | 109.5 |
| 4081 | 12.6 | 109.7 |
| 4141 | 0.0 | 109.8 |
| 4201 | 0.0 | 109.9 |
| 4261 | 0.0 | 110.2 |
| 4308 | 0.0 | 110.2 |


FTTP Graphic for Filename: XX07007
2009 MY Ford Econoline Incomplete 6.8L
Test conducted at DTF on 7/18/2007
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Fuel Temp
Trace Speed

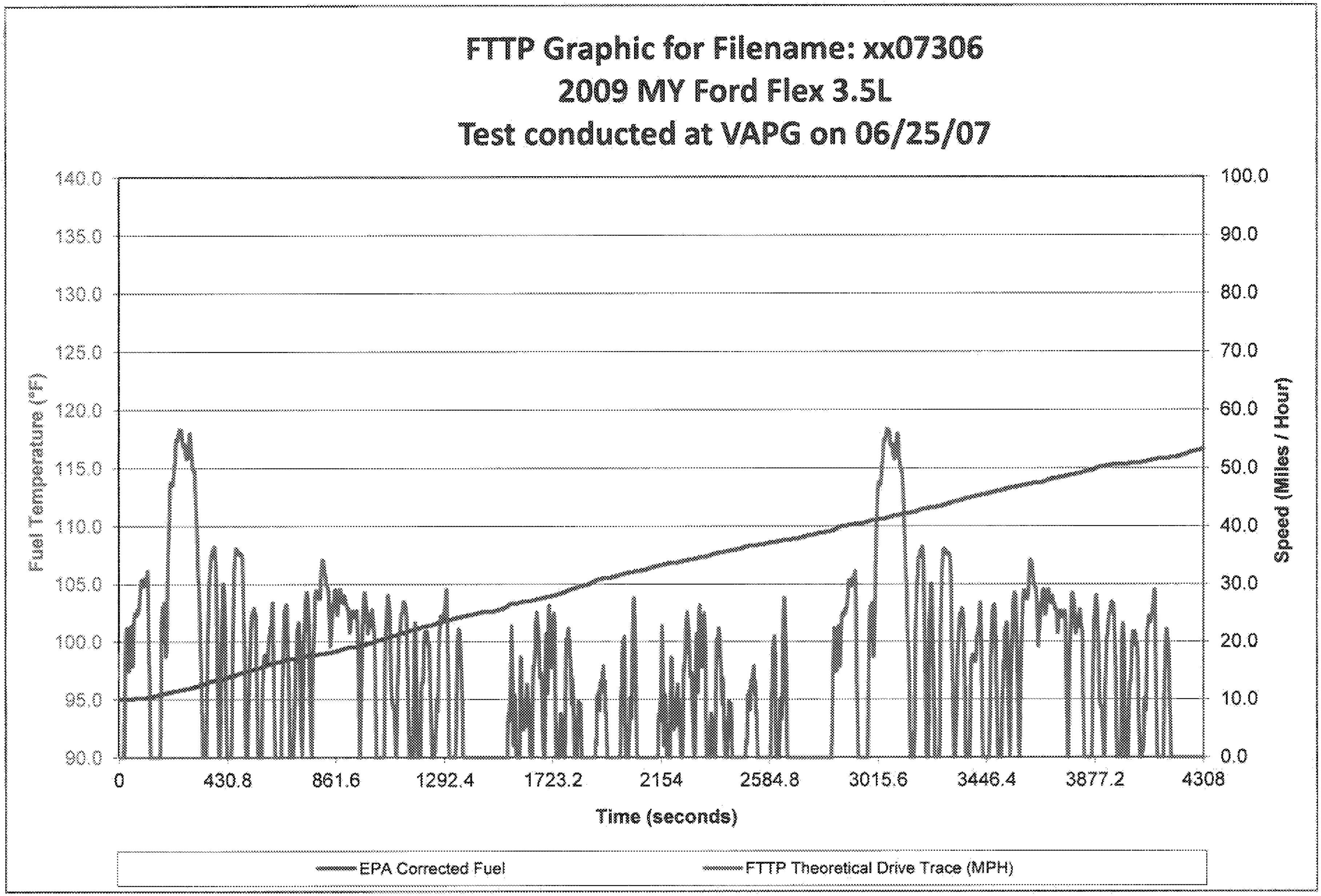
FTTP for Filename: XX07007
(used for DFMXE06.8BWX, DFMXE06.8AFA)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.1 |
| 121 | 10.3 | 95.4 |
| 181 | 26.8 | 95.6 |
| 241 | 56.6 | 95.8 |
| 301 | 48.3 | 96.1 |
| 361 | 31.9 | 96.3 |
| 421 | 23.2 | 96.5 |
| 481 | 35.1 | 96.7 |
| 541 | 25.0 | 97.0 |
| 601 | 22.2 | 97.3 |
| 661 | 26.1 | 97.5 |
| 721 | 10.4 | 97.7 |
| 781 | 28.2 | 97.9 |
| 841 | 19.7 | 98.0 |
| 901 | 26.5 | 98.2 |
| 961 | 7.1 | 98.5 |
| 1021 | 2.5 | 98.7 |
| 1081 | 13.5 | 98.9 |
| 1141 | 25.0 | 99.3 |
| 1201 | 11.0 | 99.5 |
| 1261 | 7.2 | 99.7 |
| 1321 | 0.0 | 99.9 |
| 1381 | 0.0 | 100.2 |
| 1441 | 0.0 | 100.5 |
| 1501 | 0.0 | 100.8 |
| 1561 | 21.7 | 101.1 |
| 1621 | 12.1 | 101.2 |
| 1681 | 8.0 | 101.5 |
| 1741 | 0.0 | 101.9 |
| 1801 | 12.8 | 102.1 |
| 1861 | 0.0 | 102.4 |
| 1921 | 14.3 | 102.5 |
| 1981 | 0.0 | 102.8 |
| 2041 | 22.8 | 103.0 |
| 2101 | 0.0 | 103.4 |
| 2161 | 14.5 | 103.6 |
| 2221 | 12.3 | 104.0 |
| 2281 | 3.7 | 104.3 |
| 2341 | 0.0 | 104.6 |
| 2401 | 12.3 | 104.8 |
| 2461 | 0.0 | 105.1 |
| 2521 | 15.1 | 105.3 |
| 2581 | 0.0 | 105.6 |
| 2641 | 26.0 | 105.8 |
| 2701 | 0.0 | 106.1 |
| 2761 | 0.0 | 106.4 |
| 2821 | 0.0 | 106.6 |
| 2881 | 24.6 | 106.8 |
| 2941 | 0.0 | 107.1 |
| 3001 | 19.4 | 107.4 |
| 3061 | 55.9 | 107.7 |
| 3121 | 39.3 | 108.1 |
| 3181 | 34.6 | 108.5 |
| 3241 | 0.0 | 108.8 |
| 3301 | 34.7 | 109.3 |
| 3361 | 8.1 | 109.5 |
| 3421 | 26.3 | 109.8 |
| 3481 | 24.5 | 110.1 |
| 3541 | 5.0 | 110.4 |
| 3601 | 28.3 | 110.6 |
| 3661 | 25.5 | 110.9 |
| 3721 | 25.6 | 111.2 |
| 3781 | 22.5 | 111.4 |
| 3841 | 0.0 | 111.8 |
| 3901 | 8.7 | 112.0 |
| 3961 | 8.9 | 112.2 |
| 4021 | 14.8 | 112.5 |
| 4081 | 12.6 | 112.7 |
| 4141 | 0.0 | 113.0 |
| 4201 | 0.0 | 113.2 |
| 4261 | 0.0 | 113.4 |
| 4308 | 0.0 | 113.5 |


FTTP Graphic for Filename: XX07008
2009 MY Ford F-Series 5.4L
Test conducted at DTF on 7/18/2007
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Fuel Temp
Trace Speed

FTTP for Filename: XX07008
(used for DFMXT03.73DP, DFMXT05.03D7)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.1 |
| 121 | 10.3 | 95.3 |
| 181 | 26.8 | 95.5 |
| 241 | 56.6 | 95.9 |
| 301 | 48.3 | 96.2 |
| 361 | 31.9 | 96.4 |
| 421 | 23.2 | 96.6 |
| 481 | 35.1 | 96.7 |
| 541 | 25.0 | 96.9 |
| 601 | 22.2 | 97.1 |
| 661 | 26.1 | 97.4 |
| 721 | 10.4 | 97.6 |
| 781 | 28.2 | 98.0 |
| 841 | 19.7 | 98.4 |
| 901 | 26.5 | 98.9 |
| 961 | 7.1 | 99.2 |
| 1021 | 2.5 | 99.3 |
| 1081 | 13.5 | 99.3 |
| 1141 | 25.0 | 99.6 |
| 1201 | 11.0 | 100.0 |
| 1261 | 7.2 | 100.4 |
| 1321 | 0.0 | 100.8 |
| 1381 | 0.0 | 101.2 |
| 1441 | 0.0 | 101.6 |
| 1501 | 0.0 | 101.9 |
| 1561 | 21.7 | 102.2 |
| 1621 | 12.1 | 102.4 |
| 1681 | 8.0 | 102.7 |
| 1741 | 0.0 | 103.0 |
| 1801 | 12.8 | 103.3 |
| 1861 | 0.0 | 103.5 |
| 1921 | 14.3 | 103.7 |
| 1981 | 0.0 | 104.0 |
| 2041 | 22.8 | 104.2 |
| 2101 | 0.0 | 104.5 |
| 2161 | 14.5 | 104.8 |
| 2221 | 12.3 | 105.2 |
| 2281 | 3.7 | 105.5 |
| 2341 | 0.0 | 105.9 |
| 2401 | 12.3 | 106.2 |
| 2461 | 0.0 | 106.5 |
| 2521 | 15.1 | 106.8 |
| 2581 | 0.0 | 107.1 |
| 2641 | 26.0 | 107.4 |
| 2701 | 0.0 | 107.7 |
| 2761 | 0.0 | 108.0 |
| 2821 | 0.0 | 108.3 |
| 2881 | 24.6 | 108.6 |
| 2941 | 0.0 | 109.0 |
| 3001 | 19.4 | 109.4 |
| 3061 | 55.9 | 109.8 |
| 3121 | 39.3 | 110.2 |
| 3181 | 34.6 | 110.7 |
| 3241 | 0.0 | 111.1 |
| 3301 | 34.7 | 111.5 |
| 3361 | 8.1 | 111.8 |
| 3421 | 26.3 | 112.1 |
| 3481 | 24.5 | 112.4 |
| 3541 | 5.0 | 112.7 |
| 3601 | 28.3 | 113.0 |
| 3661 | 25.5 | 113.3 |
| 3721 | 25.6 | 113.5 |
| 3781 | 22.5 | 113.8 |
| 3841 | 0.0 | 114.2 |
| 3901 | 8.7 | 114.5 |
| 3961 | 8.9 | 114.6 |
| 4021 | 14.8 | 114.9 |
| 4081 | 12.6 | 115.1 |
| 4141 | 0.0 | 115.3 |
| 4201 | 0.0 | 115.5 |
| 4261 | 0.0 | 115.7 |
| 4308 | 0.0 | 115.8 |



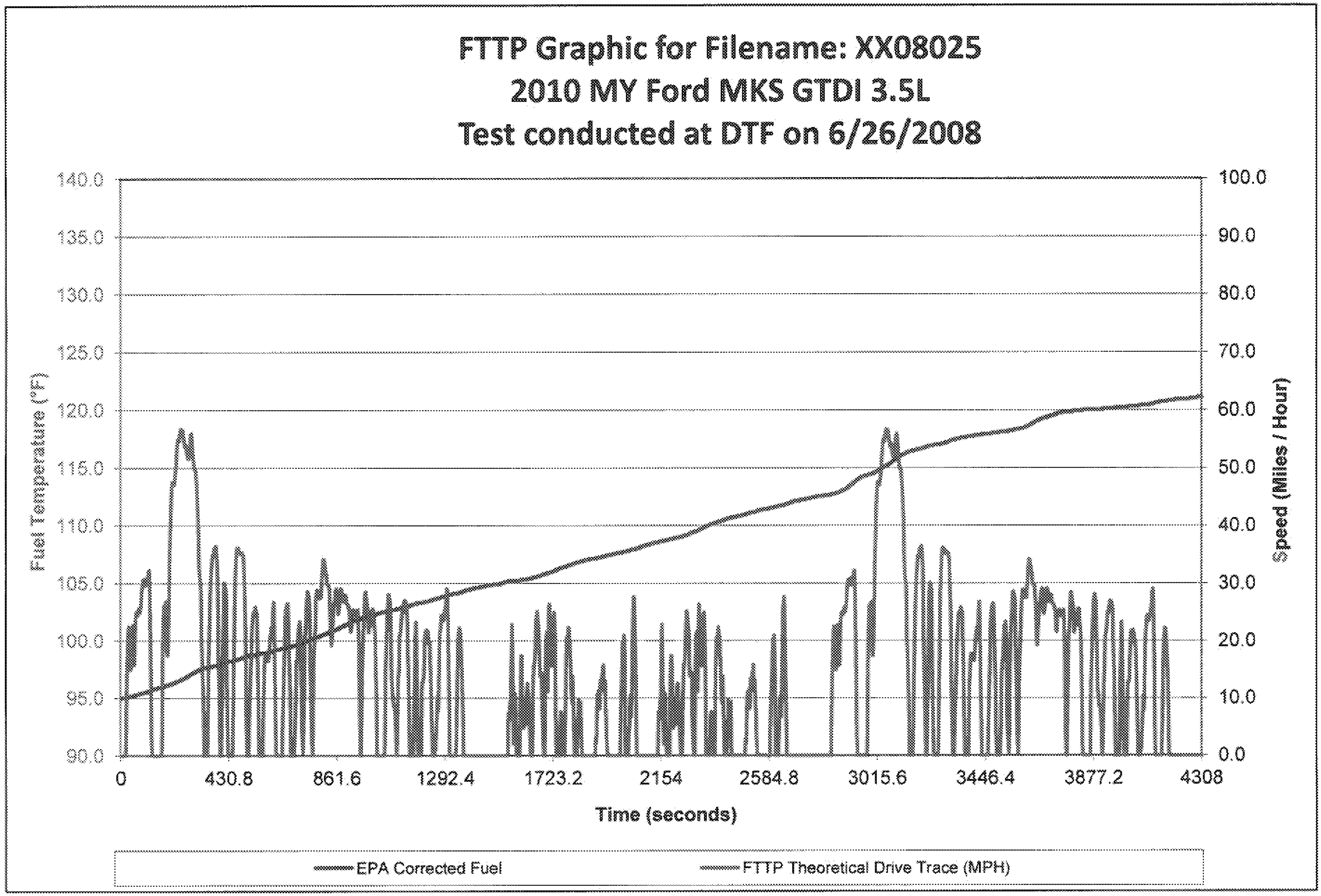

Graphic printed on:
3/2/2012 at 9:43 AM



Filename: xx07306.xls
Tab: FTTP Chart

FTTP for Filename: xx07306
(used for DFMXV03.7VE8, DFMXV03.7VHJ, DFMXT03.73E8)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.1 |
| 121 | 10.3 | 95.2 |
| 181 | 26.8 | 95.5 |
| 241 | 56.6 | 95.8 |
| 301 | 48.3 | 96.0 |
| 361 | 31.9 | 96.5 |
| 421 | 23.2 | 96.8 |
| 481 | 35.1 | 97.2 |
| 541 | 25.0 | 97.6 |
| 601 | 22.2 | 98.0 |
| 661 | 26.1 | 98.4 |
| 721 | 10.4 | 98.6 |
| 781 | 28.2 | 98.8 |
| 841 | 19.7 | 99.0 |
| 901 | 26.5 | 99.4 |
| 961 | 7.1 | 99.6 |
| 1021 | 2.5 | 100.0 |
| 1081 | 13.5 | 100.4 |
| 1141 | 25.0 | 100.8 |
| 1201 | 11.0 | 101.2 |
| 1261 | 7.2 | 101.6 |
| 1321 | 0.0 | 101.9 |
| 1381 | 0.0 | 102.2 |
| 1441 | 0.0 | 102.5 |
| 1501 | 0.0 | 102.7 |
| 1561 | 21.7 | 103.3 |
| 1621 | 12.1 | 103.5 |
| 1681 | 8.0 | 103.8 |
| 1741 | 0.0 | 104.1 |
| 1801 | 12.8 | 104.6 |
| 1861 | 0.0 | 104.9 |
| 1921 | 14.3 | 105.5 |
| 1981 | 0.0 | 105.7 |
| 2041 | 22.8 | 106.0 |
| 2101 | 0.0 | 106.3 |
| 2161 | 14.5 | 106.6 |
| 2221 | 12.3 | 106.8 |
| 2281 | 3.7 | 107.1 |
| 2341 | 0.0 | 107.4 |
| 2401 | 12.3 | 107.7 |
| 2461 | 0.0 | 108.0 |
| 2521 | 15.1 | 108.3 |
| 2581 | 0.0 | 108.5 |
| 2641 | 26.0 | 108.6 |
| 2701 | 0.0 | 108.9 |
| 2761 | 0.0 | 109.2 |
| 2821 | 0.0 | 109.5 |
| 2881 | 24.6 | 110.0 |
| 2941 | 0.0 | 110.2 |
| 3001 | 19.4 | 110.5 |
| 3061 | 55.9 | 110.8 |
| 3121 | 39.3 | 111.1 |
| 3181 | 34.6 | 111.4 |
| 3241 | 0.0 | 111.6 |
| 3301 | 34.7 | 112.0 |
| 3361 | 8.1 | 112.3 |
| 3421 | 26.3 | 112.6 |
| 3481 | 24.5 | 112.9 |
| 3541 | 5.0 | 113.3 |
| 3601 | 28.3 | 113.5 |
| 3661 | 25.5 | 113.7 |
| 3721 | 25.6 | 114.1 |
| 3781 | 22.5 | 114.4 |
| 3841 | 0.0 | 114.7 |
| 3901 | 8.7 | 115.1 |
| 3961 | 8.9 | 115.3 |
| 4021 | 14.8 | 115.4 |
| 4081 | 12.6 | 115.5 |
| 4141 | 0.0 | 115.8 |
| 4201 | 0.0 | 115.9 |
| 4261 | 0.0 | 116.4 |
| 4308 | 0.0 | 116.6 |



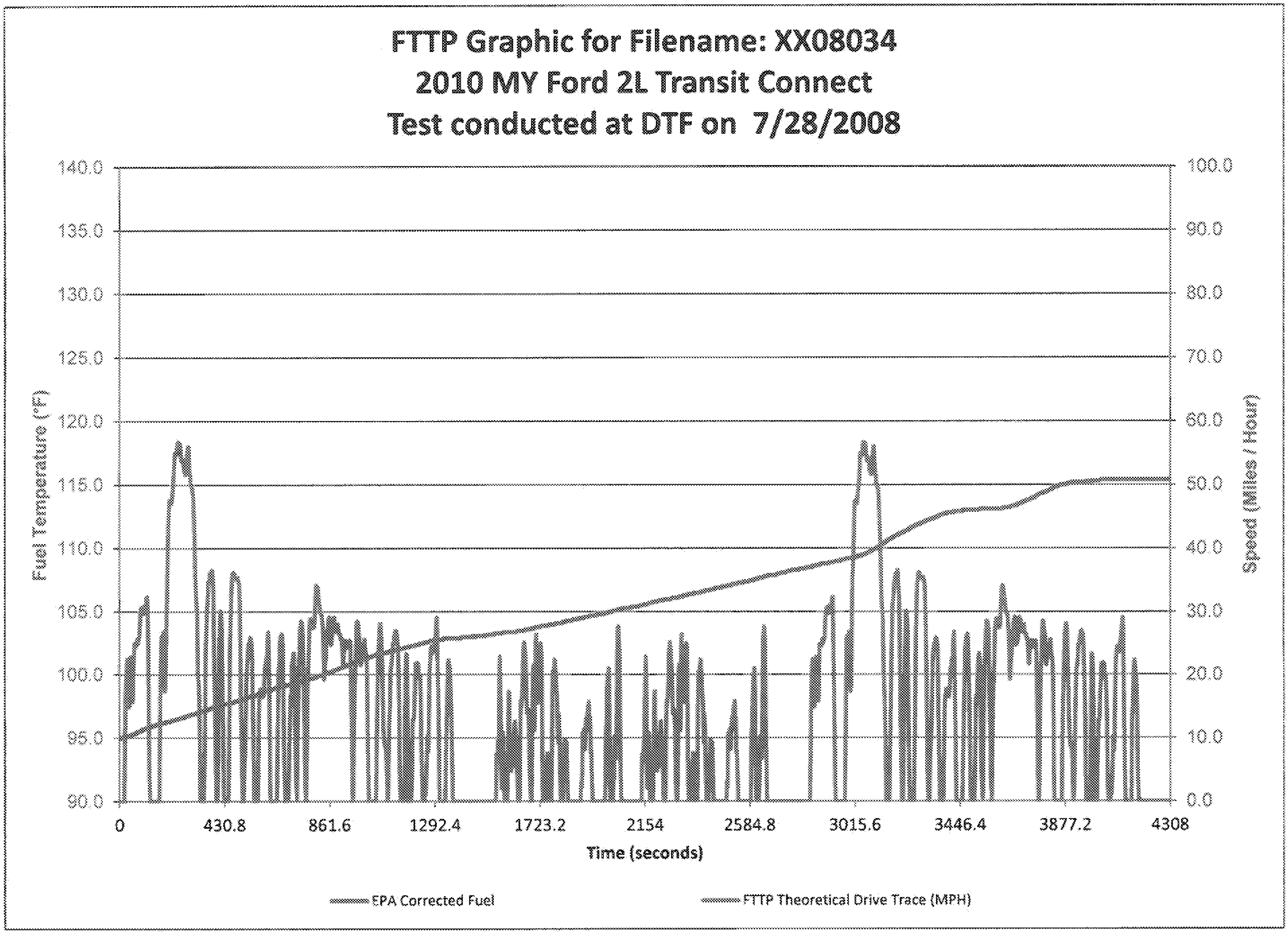

Graphic printed on:
3/2/2012 at 9:41 AM



Filename: XX08025.xls
Tab: FTTP Chart

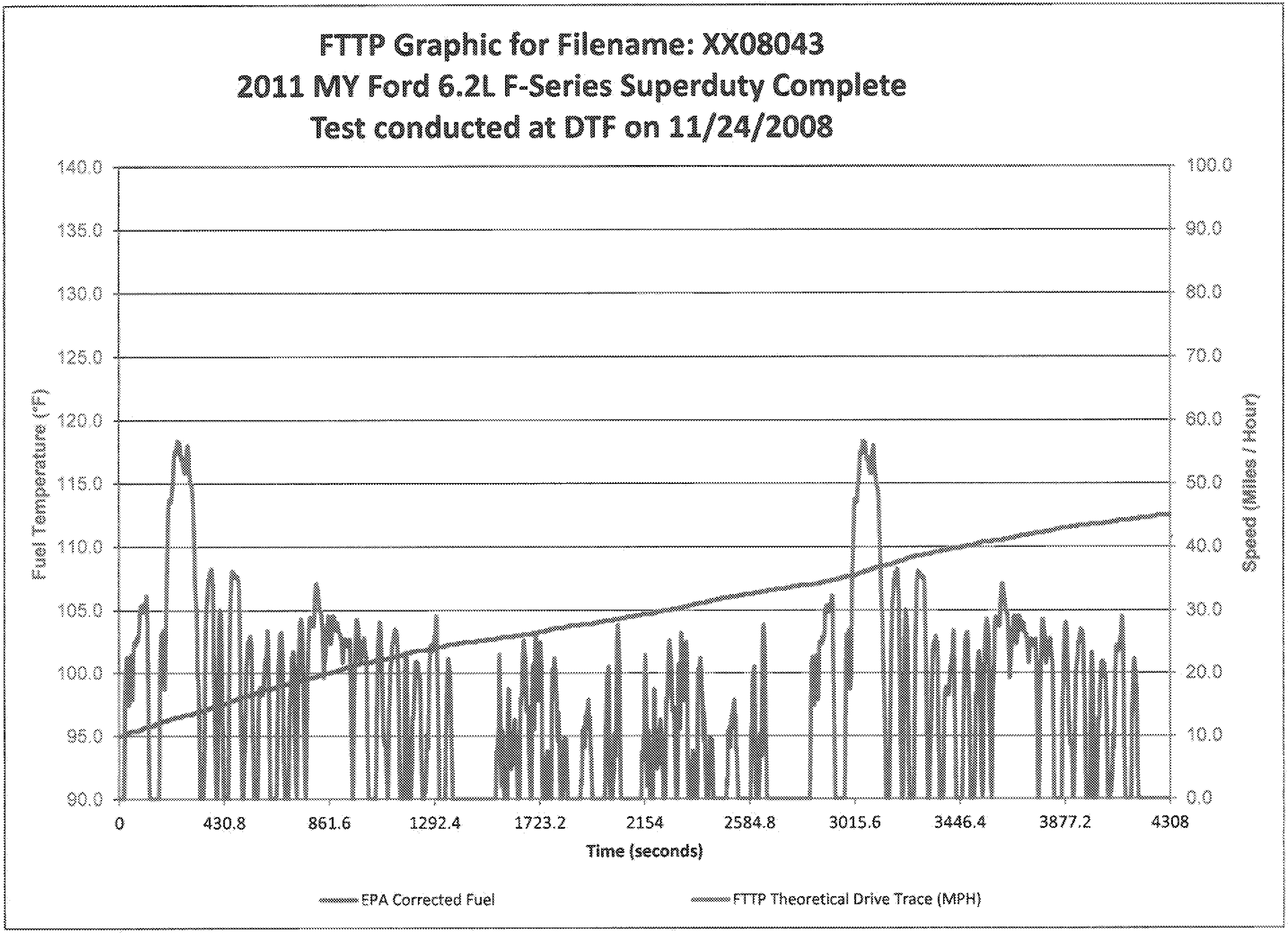
FTTP for Filename: XX08025
(used for DFMXV03.5VEP)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.3 |
| 121 | 10.3 | 95.7 |
| 181 | 26.8 | 96.1 |
| 241 | 56.6 | 96.6 |
| 301 | 48.3 | 97.3 |
| 361 | 31.9 | 97.7 |
| 421 | 23.2 | 98.1 |
| 481 | 35.1 | 98.4 |
| 541 | 25.0 | 98.8 |
| 601 | 22.2 | 99.0 |
| 661 | 26.1 | 99.4 |
| 721 | 10.4 | 99.8 |
| 781 | 28.2 | 100.3 |
| 841 | 19.7 | 100.8 |
| 901 | 26.5 | 101.4 |
| 961 | 7.1 | 102.0 |
| 1021 | 2.5 | 102.3 |
| 1081 | 13.5 | 102.7 |
| 1141 | 25.0 | 103.0 |
| 1201 | 11.0 | 103.3 |
| 1261 | 7.2 | 103.7 |
| 1321 | 0.0 | 104.0 |
| 1381 | 0.0 | 104.4 |
| 1441 | 0.0 | 104.7 |
| 1501 | 0.0 | 104.9 |
| 1561 | 21.7 | 105.2 |
| 1621 | 12.1 | 105.3 |
| 1681 | 8.0 | 105.7 |
| 1741 | 0.0 | 106.2 |
| 1801 | 12.8 | 106.6 |
| 1861 | 0.0 | 107.0 |
| 1921 | 14.3 | 107.3 |
| 1981 | 0.0 | 107.6 |
| 2041 | 22.8 | 107.9 |
| 2101 | 0.0 | 108.3 |
| 2161 | 14.5 | 108.6 |
| 2221 | 12.3 | 108.9 |
| 2281 | 3.7 | 109.4 |
| 2341 | 0.0 | 110.0 |
| 2401 | 12.3 | 110.4 |
| 2461 | 0.0 | 110.8 |
| 2521 | 15.1 | 111.1 |
| 2581 | 0.0 | 111.4 |
| 2641 | 26.0 | 111.7 |
| 2701 | 0.0 | 112.1 |
| 2761 | 0.0 | 112.4 |
| 2821 | 0.0 | 112.6 |
| 2881 | 24.6 | 113.0 |
| 2941 | 0.0 | 114.0 |
| 3001 | 19.4 | 114.5 |
| 3061 | 55.9 | 115.3 |
| 3121 | 39.3 | 116.2 |
| 3181 | 34.6 | 116.6 |
| 3241 | 0.0 | 117.0 |
| 3301 | 34.7 | 117.3 |
| 3361 | 8.1 | 117.6 |
| 3421 | 26.3 | 117.8 |
| 3481 | 24.5 | 118.0 |
| 3541 | 5.0 | 118.2 |
| 3601 | 28.3 | 118.5 |
| 3661 | 25.5 | 119.1 |
| 3721 | 25.6 | 119.6 |
| 3781 | 22.5 | 119.8 |
| 3841 | 0.0 | 120.0 |
| 3901 | 8.7 | 120.0 |
| 3961 | 8.9 | 120.1 |
| 4021 | 14.8 | 120.3 |
| 4081 | 12.6 | 120.4 |
| 4141 | 0.0 | 120.7 |
| 4201 | 0.0 | 120.8 |
| 4261 | 0.0 | 121.0 |
| 4308 | 0.0 | 121.1 |


FTTP Graphic for Filename: XX08034
2010 MY Ford 2L Transit Connect
Test conducted at DTF on 7/28/2008
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

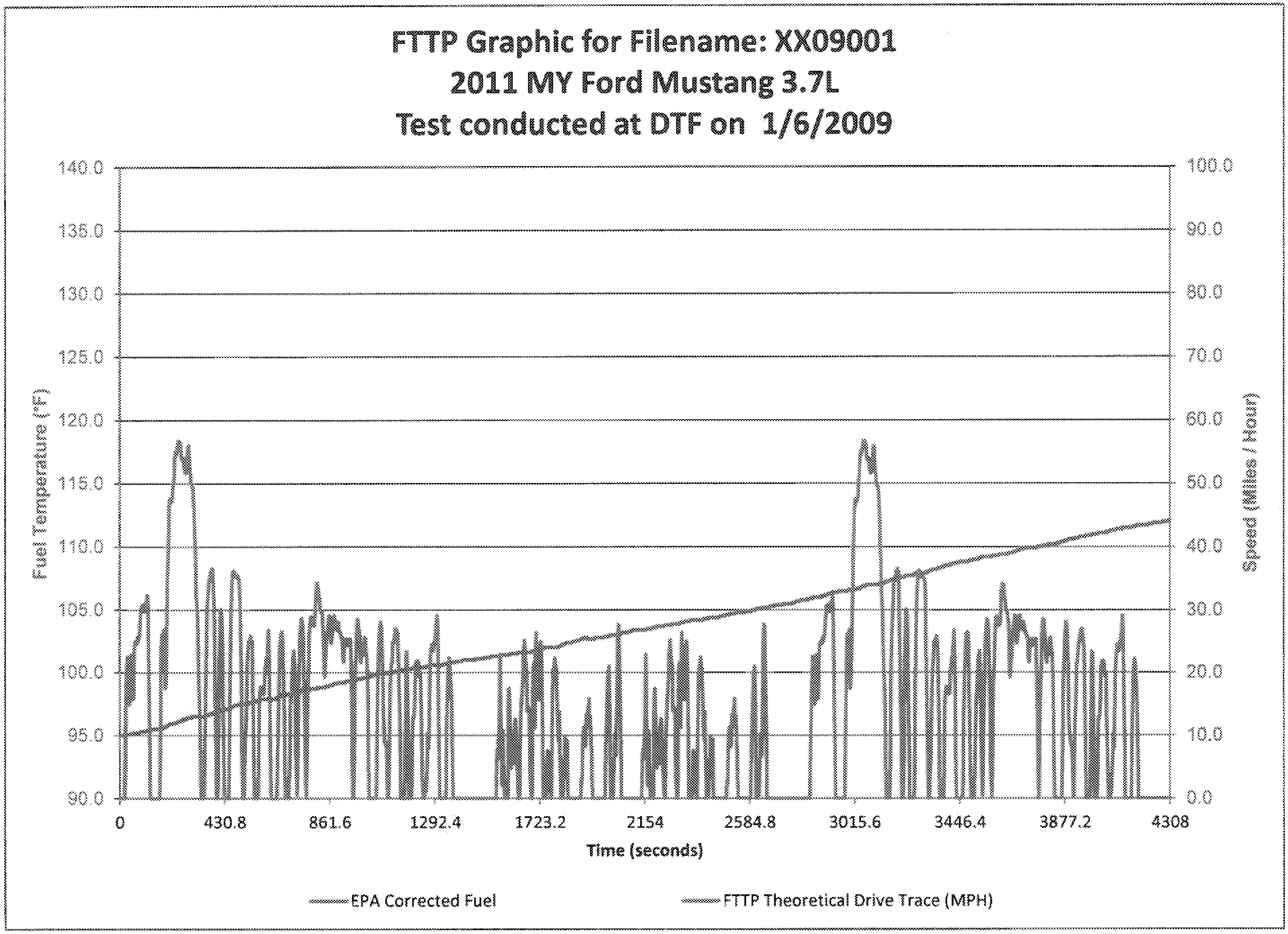
FTTP for Filename: XX08034
(used for DFMXV05.8VE2, DFMXT02.01DW)

| Time<br>Sec | Trace Speed<br>MPH | EPA Fuel Temp<br>°F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.4 |
| 121 | 10.3 | 95.8 |
| 181 | 26.8 | 96.2 |
| 241 | 56.6 | 96.5 |
| 301 | 48.3 | 96.9 |
| 361 | 31.9 | 97.3 |
| 421 | 23.2 | 97.6 |
| 481 | 35.1 | 97.9 |
| 541 | 25.0 | 98.3 |
| 601 | 22.2 | 98.7 |
| 661 | 26.1 | 99.1 |
| 721 | 10.4 | 99.3 |
| 781 | 28.2 | 99.7 |
| 841 | 19.7 | 100.0 |
| 901 | 26.5 | 100.5 |
| 961 | 7.1 | 100.9 |
| 1021 | 2.5 | 101.3 |
| 1081 | 13.5 | 101.7 |
| 1141 | 25.0 | 102.0 |
| 1201 | 11.0 | 102.3 |
| 1261 | 7.2 | 102.6 |
| 1321 | 0.0 | 102.8 |
| 1381 | 0.0 | 102.9 |
| 1441 | 0.0 | 103.0 |
| 1501 | 0.0 | 103.1 |
| 1561 | 21.7 | 103.3 |
| 1621 | 12.1 | 103.4 |
| 1681 | 8.0 | 103.6 |
| 1741 | 0.0 | 103.9 |
| 1801 | 12.8 | 104.1 |
| 1861 | 0.0 | 104.4 |
| 1921 | 14.3 | 104.6 |
| 1981 | 0.0 | 104.8 |
| 2041 | 22.8 | 105.1 |
| 2101 | 0.0 | 105.4 |
| 2161 | 14.5 | 105.6 |
| 2221 | 12.3 | 105.9 |
| 2281 | 3.7 | 106.1 |
| 2341 | 0.0 | 106.4 |
| 2401 | 12.3 | 106.6 |
| 2461 | 0.0 | 106.9 |
| 2521 | 15.1 | 107.2 |
| 2581 | 0.0 | 107.4 |
| 2641 | 26.0 | 107.7 |
| 2701 | 0.0 | 108.0 |
| 2761 | 0.0 | 108.3 |
| 2821 | 0.0 | 108.5 |
| 2881 | 24.6 | 108.8 |
| 2941 | 0.0 | 109.0 |
| 3001 | 19.4 | 109.2 |
| 3061 | 55.9 | 109.6 |
| 3121 | 39.3 | 110.2 |
| 3181 | 34.6 | 110.9 |
| 3241 | 0.0 | 111.5 |
| 3301 | 34.7 | 112.1 |
| 3361 | 8.1 | 112.5 |
| 3421 | 26.3 | 112.8 |
| 3481 | 24.5 | 113.0 |
| 3541 | 5.0 | 113.1 |
| 3601 | 28.3 | 113.1 |
| 3661 | 25.5 | 113.3 |
| 3721 | 25.6 | 113.8 |
| 3781 | 22.5 | 114.3 |
| 3841 | 0.0 | 114.8 |
| 3901 | 8.7 | 115.1 |
| 3961 | 8.9 | 115.2 |
| 4021 | 14.8 | 115.3 |
| 4081 | 12.6 | 115.4 |
| 4141 | 0.0 | 115.4 |
| 4201 | 0.0 | 115.4 |
| 4261 | 0.0 | 115.4 |
| 4308 | 0.0 | 115.4 |


FTTP Graphic for Filename: XX08043
2011 MY Ford 6.2L F-Series Superduty Complete
Test conducted at DTF on 11/24/2008
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

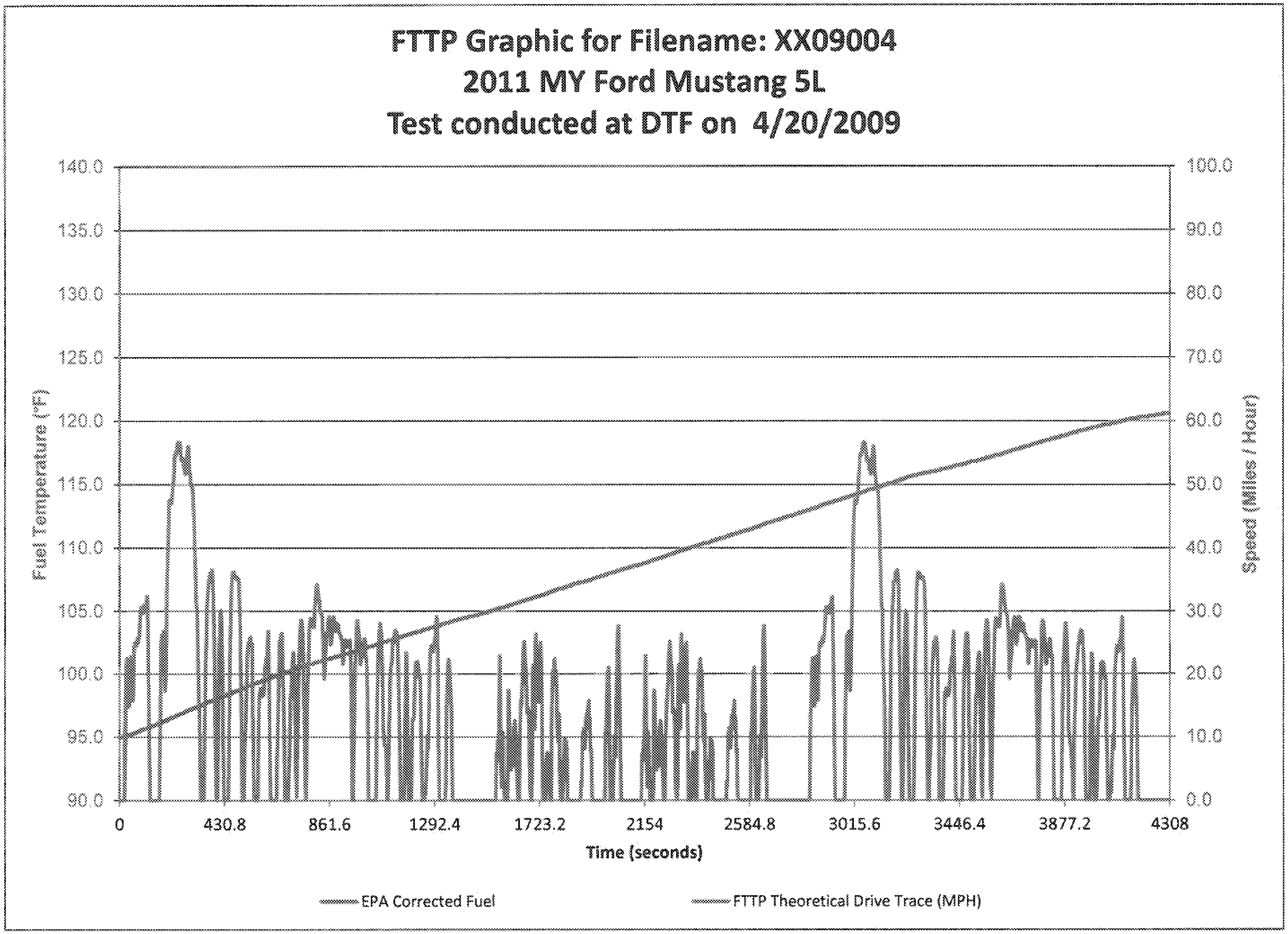
FTTP for Filename: XX08043
(used for DFMXT06.27HL)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.4 |
| 121 | 10.3 | 95.8 |
| 181 | 26.8 | 96.2 |
| 241 | 56.6 | 96.5 |
| 301 | 48.3 | 96.8 |
| 361 | 31.9 | 97.1 |
| 421 | 23.2 | 97.5 |
| 481 | 35.1 | 97.9 |
| 541 | 25.0 | 98.3 |
| 601 | 22.2 | 98.7 |
| 661 | 26.1 | 99.0 |
| 721 | 10.4 | 99.3 |
| 781 | 28.2 | 99.6 |
| 841 | 19.7 | 99.9 |
| 901 | 26.5 | 100.2 |
| 961 | 7.1 | 100.6 |
| 1021 | 2.5 | 100.8 |
| 1081 | 13.5 | 101.1 |
| 1141 | 25.0 | 101.4 |
| 1201 | 11.0 | 101.7 |
| 1261 | 7.2 | 101.9 |
| 1321 | 0.0 | 102.1 |
| 1381 | 0.0 | 102.3 |
| 1441 | 0.0 | 102.5 |
| 1501 | 0.0 | 102.6 |
| 1561 | 21.7 | 102.8 |
| 1621 | 12.1 | 102.9 |
| 1681 | 8.0 | 103.1 |
| 1741 | 0.0 | 103.3 |
| 1801 | 12.8 | 103.6 |
| 1861 | 0.0 | 103.8 |
| 1921 | 14.3 | 103.9 |
| 1981 | 0.0 | 104.1 |
| 2041 | 22.8 | 104.3 |
| 2101 | 0.0 | 104.5 |
| 2161 | 14.5 | 104.7 |
| 2221 | 12.3 | 104.9 |
| 2281 | 3.7 | 105.1 |
| 2341 | 0.0 | 105.4 |
| 2401 | 12.3 | 105.6 |
| 2461 | 0.0 | 105.9 |
| 2521 | 15.1 | 106.1 |
| 2581 | 0.0 | 106.3 |
| 2641 | 26.0 | 106.5 |
| 2701 | 0.0 | 106.7 |
| 2761 | 0.0 | 106.9 |
| 2821 | 0.0 | 107.0 |
| 2881 | 24.6 | 107.2 |
| 2941 | 0.0 | 107.4 |
| 3001 | 19.4 | 107.7 |
| 3061 | 55.9 | 108.1 |
| 3121 | 39.3 | 108.5 |
| 3181 | 34.6 | 108.7 |
| 3241 | 0.0 | 109.1 |
| 3301 | 34.7 | 109.4 |
| 3361 | 8.1 | 109.6 |
| 3421 | 26.3 | 109.9 |
| 3481 | 24.5 | 110.1 |
| 3541 | 5.0 | 110.4 |
| 3601 | 28.3 | 110.5 |
| 3661 | 25.5 | 110.7 |
| 3721 | 25.6 | 110.9 |
| 3781 | 22.5 | 111.1 |
| 3841 | 0.0 | 111.4 |
| 3901 | 8.7 | 111.6 |
| 3961 | 8.9 | 111.7 |
| 4021 | 14.8 | 111.8 |
| 4081 | 12.6 | 112.0 |
| 4141 | 0.0 | 112.1 |
| 4201 | 0.0 | 112.3 |
| 4261 | 0.0 | 112.5 |
| 4308 | 0.0 | 112.5 |


FTTP Graphic for Filename: XX09001
2011 MY Ford Mustang 3.7L
Test conducted at DTF on 1/6/2009
Fuel Temperature (°F)
Speed (Miles / Hour)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

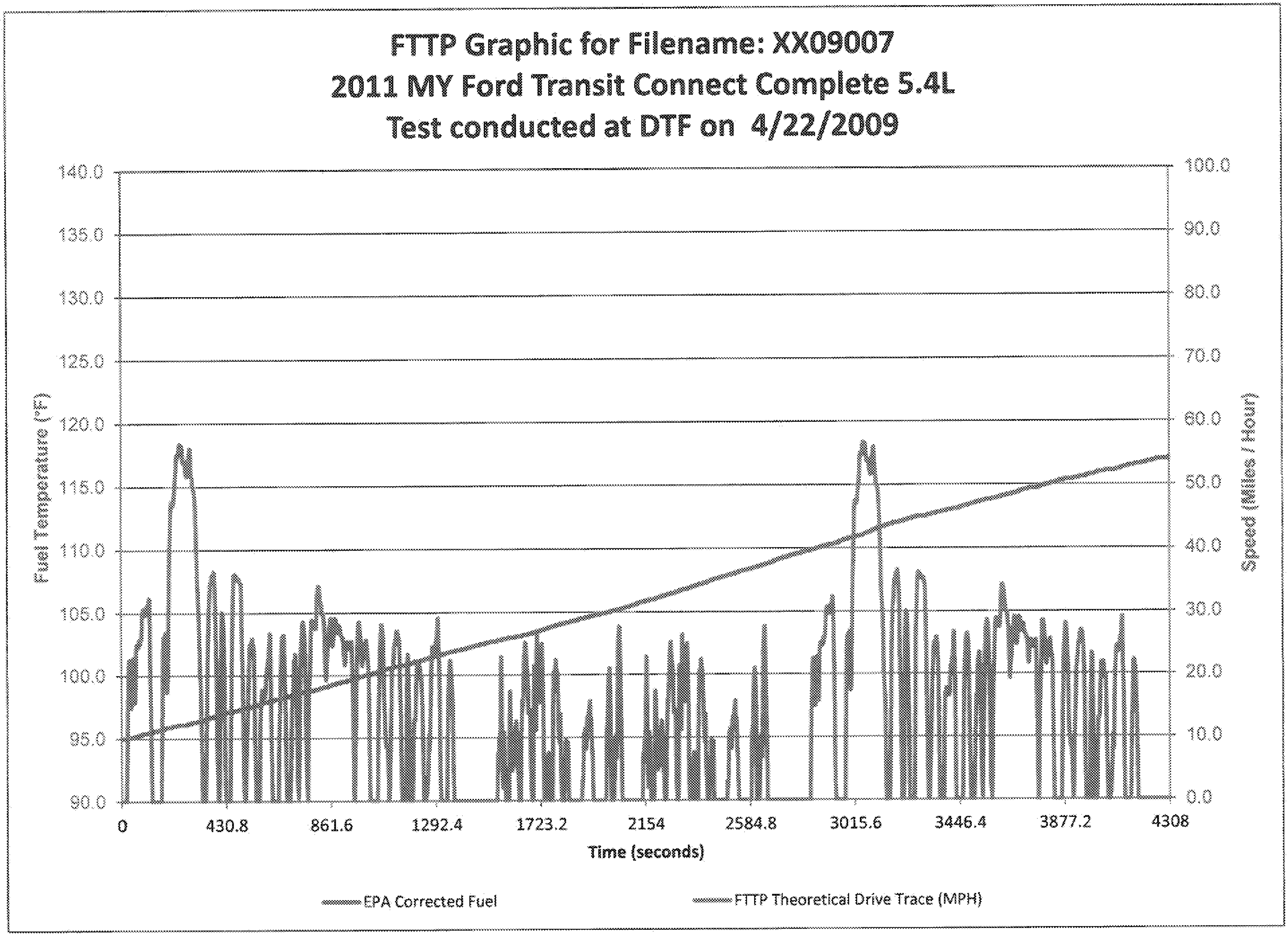
FTTP for Filename: XX09001
(used for DFMXV03.7VDT)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.2 |
| 121 | 10.3 | 95.4 |
| 181 | 26.8 | 95.6 |
| 241 | 56.6 | 96.1 |
| 301 | 48.3 | 96.5 |
| 361 | 31.9 | 96.6 |
| 421 | 23.2 | 97.0 |
| 481 | 35.1 | 97.4 |
| 541 | 25.0 | 97.6 |
| 601 | 22.2 | 97.9 |
| 661 | 26.1 | 98.1 |
| 721 | 10.4 | 98.4 |
| 781 | 28.2 | 98.6 |
| 841 | 19.7 | 98.8 |
| 901 | 26.5 | 99.2 |
| 961 | 7.1 | 99.4 |
| 1021 | 2.5 | 99.7 |
| 1081 | 13.5 | 99.9 |
| 1141 | 25.0 | 100.1 |
| 1201 | 11.0 | 100.3 |
| 1261 | 7.2 | 100.5 |
| 1321 | 0.0 | 100.6 |
| 1381 | 0.0 | 100.9 |
| 1441 | 0.0 | 101.0 |
| 1501 | 0.0 | 101.2 |
| 1561 | 21.7 | 101.4 |
| 1621 | 12.1 | 101.5 |
| 1681 | 8.0 | 101.6 |
| 1741 | 0.0 | 102.0 |
| 1801 | 12.8 | 102.1 |
| 1861 | 0.0 | 102.5 |
| 1921 | 14.3 | 102.7 |
| 1981 | 0.0 | 102.8 |
| 2041 | 22.8 | 103.1 |
| 2101 | 0.0 | 103.3 |
| 2161 | 14.5 | 103.5 |
| 2221 | 12.3 | 103.7 |
| 2281 | 3.7 | 103.9 |
| 2341 | 0.0 | 104.2 |
| 2401 | 12.3 | 104.3 |
| 2461 | 0.0 | 104.5 |
| 2521 | 15.1 | 104.7 |
| 2581 | 0.0 | 104.9 |
| 2641 | 26.0 | 105.2 |
| 2701 | 0.0 | 105.4 |
| 2761 | 0.0 | 105.5 |
| 2821 | 0.0 | 105.8 |
| 2881 | 24.6 | 106.1 |
| 2941 | 0.0 | 106.4 |
| 3001 | 19.4 | 106.8 |
| 3061 | 55.9 | 107.0 |
| 3121 | 39.3 | 107.1 |
| 3181 | 34.6 | 107.5 |
| 3241 | 0.0 | 107.7 |
| 3301 | 34.7 | 107.9 |
| 3361 | 8.1 | 108.3 |
| 3421 | 26.3 | 108.6 |
| 3481 | 24.5 | 108.8 |
| 3541 | 5.0 | 109.2 |
| 3601 | 28.3 | 109.3 |
| 3661 | 25.5 | 109.5 |
| 3721 | 25.6 | 109.9 |
| 3781 | 22.5 | 110.0 |
| 3841 | 0.0 | 110.2 |
| 3901 | 8.7 | 110.6 |
| 3961 | 8.9 | 110.9 |
| 4021 | 14.8 | 111.1 |
| 4081 | 12.6 | 111.3 |
| 4141 | 0.0 | 111.5 |
| 4201 | 0.0 | 111.7 |
| 4261 | 0.0 | 111.9 |
| 4308 | 0.0 | 112.1 |


FTTP Graphic for Filename: XX09004
2011 MY Ford Mustang 5L
Test conducted at DTF on 4/20/2009
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

FTTP for Filename: XX09004
(used for DFMXV05.0VD5)

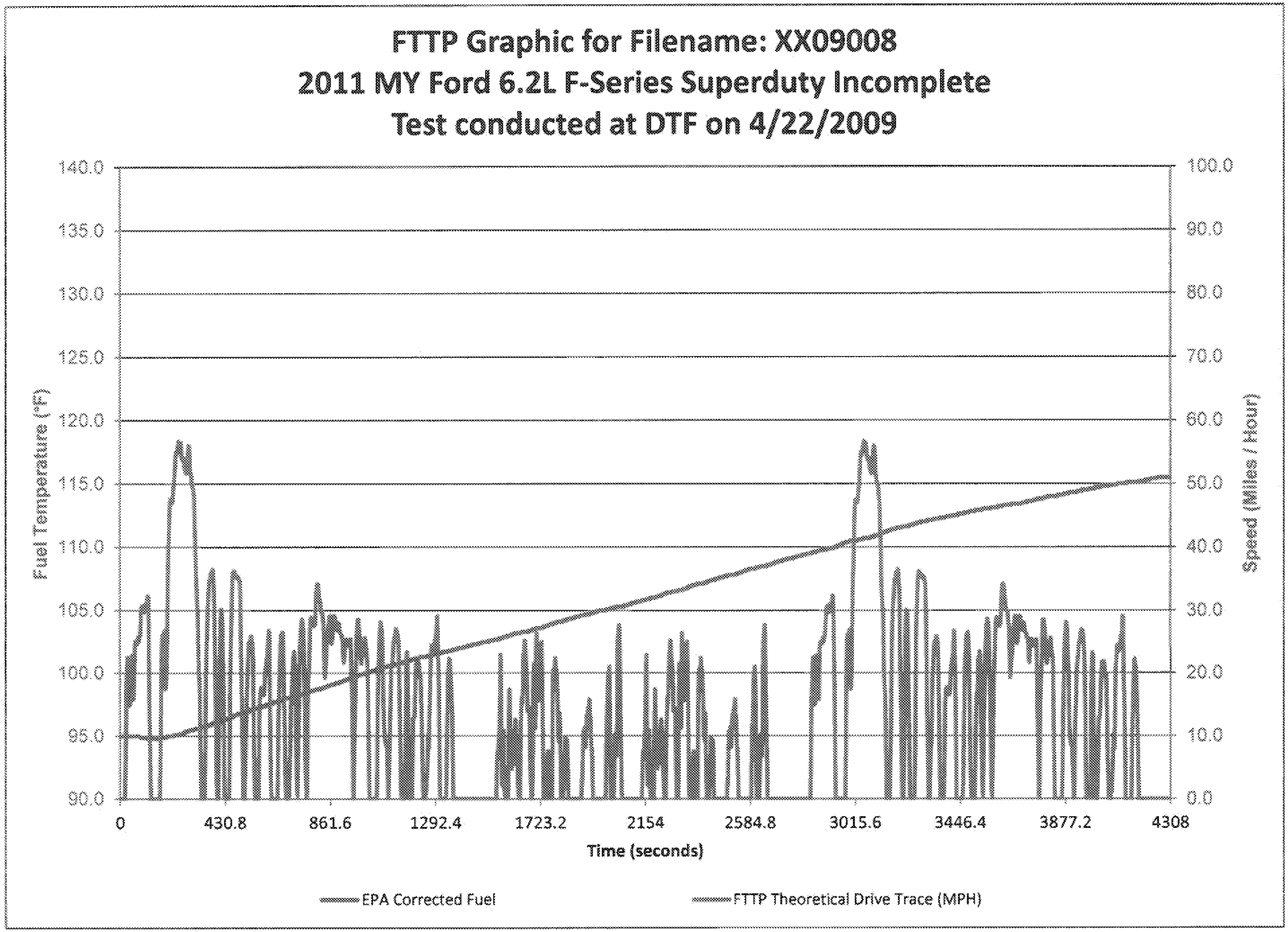
| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.3 |
| 121 | 10.3 | 95.8 |
| 181 | 26.8 | 96.3 |
| 241 | 56.6 | 96.8 |
| 301 | 48.3 | 97.3 |
| 361 | 31.9 | 97.8 |
| 421 | 23.2 | 98.2 |
| 481 | 35.1 | 98.7 |
| 541 | 25.0 | 99.1 |
| 601 | 22.2 | 99.6 |
| 661 | 26.1 | 100.0 |
| 721 | 10.4 | 100.4 |
| 781 | 28.2 | 100.8 |
| 841 | 19.7 | 101.1 |
| 901 | 26.5 | 101.4 |
| 961 | 7.1 | 101.8 |
| 1021 | 2.5 | 102.2 |
| 1081 | 13.5 | 102.5 |
| 1141 | 25.0 | 102.9 |
| 1201 | 11.0 | 103.3 |
| 1261 | 7.2 | 103.6 |
| 1321 | 0.0 | 104.0 |
| 1381 | 0.0 | 104.3 |
| 1441 | 0.0 | 104.6 |
| 1501 | 0.0 | 104.9 |
| 1561 | 21.7 | 105.3 |
| 1621 | 12.1 | 105.6 |
| 1681 | 8.0 | 106.0 |
| 1741 | 0.0 | 106.3 |
| 1801 | 12.8 | 106.8 |
| 1861 | 0.0 | 107.1 |
| 1921 | 14.3 | 107.4 |
| 1981 | 0.0 | 107.8 |
| 2041 | 22.8 | 108.2 |
| 2101 | 0.0 | 108.5 |
| 2161 | 14.5 | 108.8 |
| 2221 | 12.3 | 109.2 |
| 2281 | 3.7 | 109.6 |
| 2341 | 0.0 | 110.0 |
| 2401 | 12.3 | 110.4 |
| 2461 | 0.0 | 110.7 |
| 2521 | 15.1 | 111.1 |
| 2581 | 0.0 | 111.4 |
| 2641 | 26.0 | 111.9 |
| 2701 | 0.0 | 112.2 |
| 2761 | 0.0 | 112.6 |
| 2821 | 0.0 | 113.0 |
| 2881 | 24.6 | 113.3 |
| 2941 | 0.0 | 113.7 |
| 3001 | 19.4 | 114.1 |
| 3061 | 55.9 | 114.5 |
| 3121 | 39.3 | 114.8 |
| 3181 | 34.6 | 115.2 |
| 3241 | 0.0 | 115.6 |
| 3301 | 34.7 | 115.9 |
| 3361 | 6.1 | 116.1 |
| 3421 | 26.3 | 116.4 |
| 3481 | 24.5 | 116.7 |
| 3541 | 5.0 | 117.0 |
| 3601 | 28.3 | 117.3 |
| 3661 | 25.5 | 117.7 |
| 3721 | 25.6 | 118.0 |
| 3781 | 22.5 | 118.3 |
| 3841 | 0.0 | 118.7 |
| 3901 | 8.7 | 119.0 |
| 3961 | 8.9 | 119.3 |
| 4021 | 14.8 | 119.6 |
| 4081 | 12.6 | 119.8 |
| 4141 | 0.0 | 120.1 |
| 4201 | 0.0 | 120.3 |
| 4261 | 0.0 | 120.5 |
| 4308 | 0.0 | 120.6 |



FTTP Graphic for Filename: XX09007
2011 MY Ford Transit Connect Complete 5.4L
Test conducted at DTF on 4/22/2009
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

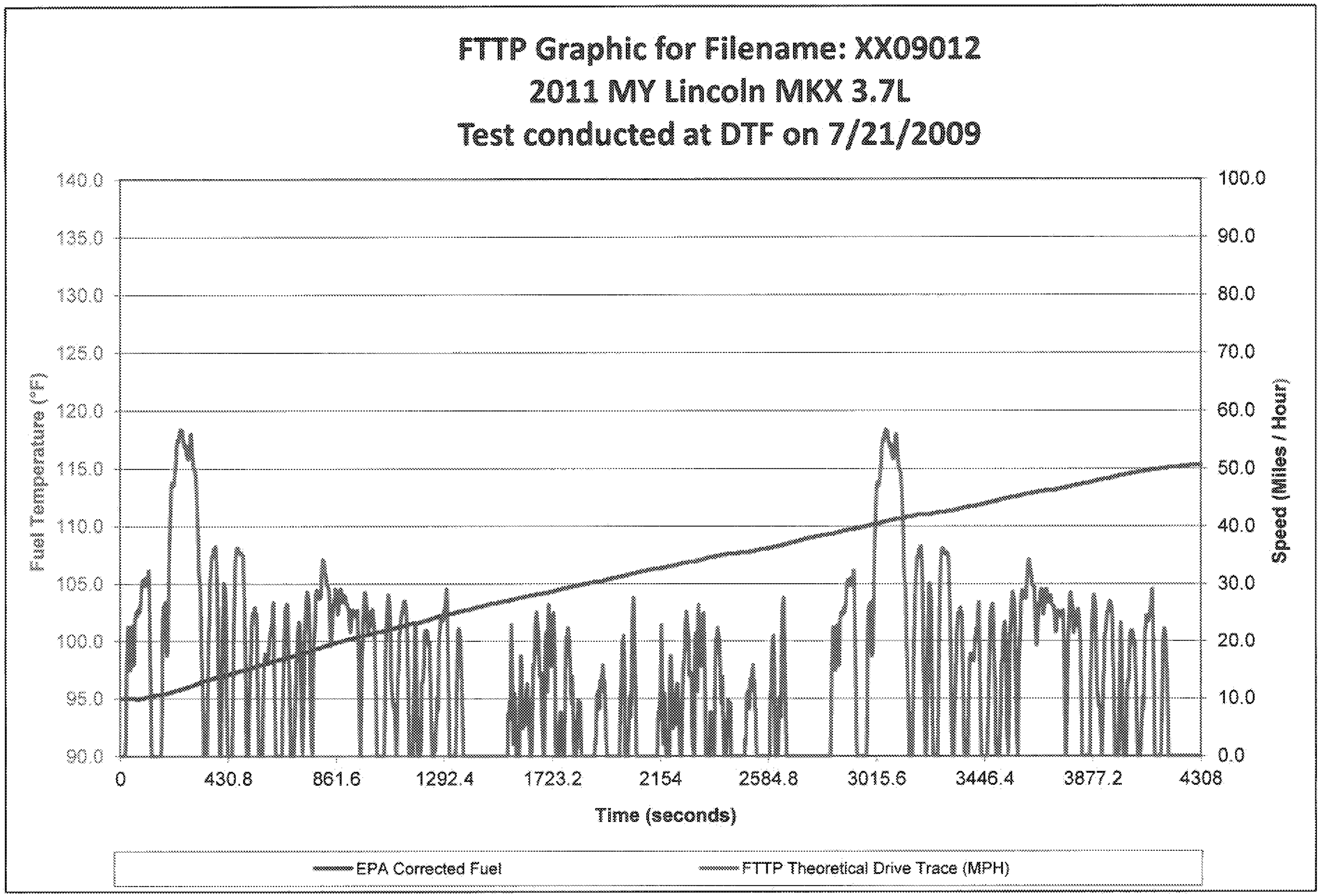
FTTP for Filename: XX09007
(used for DFMXT05.45HL, DFMXT06.85HT, DFMXT04.65H9, DFMXT05.45HK)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.2 |
| 121 | 10.3 | 95.5 |
| 181 | 26.8 | 95.8 |
| 241 | 56.6 | 96.1 |
| 301 | 48.3 | 96.3 |
| 361 | 31.9 | 96.6 |
| 421 | 23.2 | 97.0 |
| 481 | 35.1 | 97.3 |
| 541 | 25.0 | 97.6 |
| 601 | 22.2 | 97.9 |
| 661 | 26.1 | 98.2 |
| 721 | 10.4 | 98.5 |
| 781 | 28.2 | 98.8 |
| 841 | 19.7 | 99.1 |
| 901 | 26.5 | 99.4 |
| 961 | 7.1 | 99.8 |
| 1021 | 2.5 | 100.1 |
| 1081 | 13.5 | 100.5 |
| 1141 | 25.0 | 100.7 |
| 1201 | 11.0 | 101.0 |
| 1261 | 7.2 | 101.4 |
| 1321 | 0.0 | 101.7 |
| 1381 | 0.0 | 102.0 |
| 1441 | 0.0 | 102.3 |
| 1501 | 0.0 | 102.6 |
| 1561 | 21.7 | 102.8 |
| 1621 | 12.1 | 103.1 |
| 1681 | 8.0 | 103.3 |
| 1741 | 0.0 | 103.7 |
| 1801 | 12.8 | 104.0 |
| 1861 | 0.0 | 104.3 |
| 1921 | 14.3 | 104.6 |
| 1981 | 0.0 | 104.9 |
| 2041 | 22.8 | 105.2 |
| 2101 | 0.0 | 105.5 |
| 2161 | 14.5 | 105.9 |
| 2221 | 12.3 | 106.2 |
| 2281 | 3.7 | 106.6 |
| 2341 | 0.0 | 106.9 |
| 2401 | 12.3 | 107.3 |
| 2461 | 0.0 | 107.7 |
| 2521 | 15.1 | 108.0 |
| 2581 | 0.0 | 108.4 |
| 2641 | 26.0 | 108.7 |
| 2701 | 0.0 | 109.1 |
| 2761 | 0.0 | 109.5 |
| 2821 | 0.0 | 109.8 |
| 2881 | 24.6 | 110.1 |
| 2941 | 0.0 | 110.4 |
| 3001 | 19.4 | 110.8 |
| 3061 | 55.9 | 111.1 |
| 3121 | 39.3 | 111.6 |
| 3181 | 34.6 | 112.0 |
| 3241 | 0.0 | 112.3 |
| 3301 | 34.7 | 112.5 |
| 3361 | 8.1 | 112.8 |
| 3421 | 26.3 | 113.1 |
| 3481 | 24.5 | 113.4 |
| 3541 | 5.0 | 113.7 |
| 3601 | 28.3 | 113.9 |
| 3661 | 25.5 | 114.2 |
| 3721 | 25.6 | 114.6 |
| 3781 | 22.5 | 114.8 |
| 3841 | 0.0 | 115.2 |
| 3901 | 8.7 | 115.4 |
| 3961 | 8.9 | 115.6 |
| 4021 | 14.8 | 116.0 |
| 4081 | 12.6 | 116.1 |
| 4141 | 0.0 | 116.5 |
| 4201 | 0.0 | 116.7 |
| 4261 | 0.0 | 117.0 |
| 4308 | 0.0 | 117.1 |


FTTP Graphic for Filename: XX09008
2011 MY Ford 6.2L F-Series Superduty Incomplete
Test conducted at DTF on 4/22/2009
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

FTTP for Filename: XX09008
(used for DFMXT06.27HL Chasis Cab)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.0 |
| 121 | 10.3 | 94.8 |
| 181 | 26.8 | 94.9 |
| 241 | 56.6 | 95.1 |
| 301 | 48.3 | 95.5 |
| 361 | 31.9 | 95.8 |
| 421 | 23.2 | 96.3 |
| 481 | 35.1 | 96.7 |
| 541 | 25.0 | 97.1 |
| 601 | 22.2 | 97.5 |
| 661 | 26.1 | 97.9 |
| 721 | 10.4 | 98.2 |
| 781 | 28.2 | 98.5 |
| 841 | 19.7 | 98.9 |
| 901 | 26.5 | 99.3 |
| 961 | 7.1 | 99.7 |
| 1021 | 2.5 | 100.1 |
| 1081 | 13.5 | 100.4 |
| 1141 | 25.0 | 100.7 |
| 1201 | 11.0 | 101.1 |
| 1261 | 7.2 | 101.4 |
| 1321 | 0.0 | 101.7 |
| 1381 | 0.0 | 101.9 |
| 1441 | 0.0 | 102.2 |
| 1501 | 0.0 | 102.5 |
| 1561 | 21.7 | 102.8 |
| 1621 | 12.1 | 103.2 |
| 1681 | 8.0 | 103.4 |
| 1741 | 0.0 | 103.7 |
| 1801 | 12.8 | 104.1 |
| 1861 | 0.0 | 104.4 |
| 1921 | 14.3 | 104.7 |
| 1981 | 0.0 | 105.0 |
| 2041 | 22.8 | 105.3 |
| 2101 | 0.0 | 105.6 |
| 2161 | 14.5 | 105.9 |
| 2221 | 12.3 | 106.2 |
| 2281 | 3.7 | 106.5 |
| 2341 | 0.0 | 106.9 |
| 2401 | 12.3 | 107.2 |
| 2461 | 0.0 | 107.6 |
| 2521 | 15.1 | 107.8 |
| 2581 | 0.0 | 108.3 |
| 2641 | 26.0 | 108.5 |
| 2701 | 0.0 | 108.9 |
| 2761 | 0.0 | 109.2 |
| 2821 | 0.0 | 109.5 |
| 2881 | 24.6 | 109.8 |
| 2941 | 0.0 | 110.0 |
| 3001 | 19.4 | 110.5 |
| 3061 | 55.9 | 110.7 |
| 3121 | 39.3 | 111.0 |
| 3181 | 34.6 | 111.4 |
| 3241 | 0.0 | 111.7 |
| 3301 | 34.7 | 112.0 |
| 3361 | 8.1 | 112.3 |
| 3421 | 26.3 | 112.5 |
| 3481 | 24.5 | 112.7 |
| 3541 | 5.0 | 113.0 |
| 3601 | 28.3 | 113.2 |
| 3661 | 25.5 | 113.4 |
| 3721 | 25.6 | 113.6 |
| 3781 | 22.5 | 113.8 |
| 3841 | 0.0 | 114.0 |
| 3901 | 8.7 | 114.3 |
| 3961 | 8.9 | 114.5 |
| 4021 | 14.6 | 114.7 |
| 4081 | 12.6 | 114.9 |
| 4141 | 0.0 | 115.1 |
| 4201 | 0.0 | 115.2 |
| 4261 | 0.0 | 115.5 |
| 4308 | 0.0 | 115.5 |



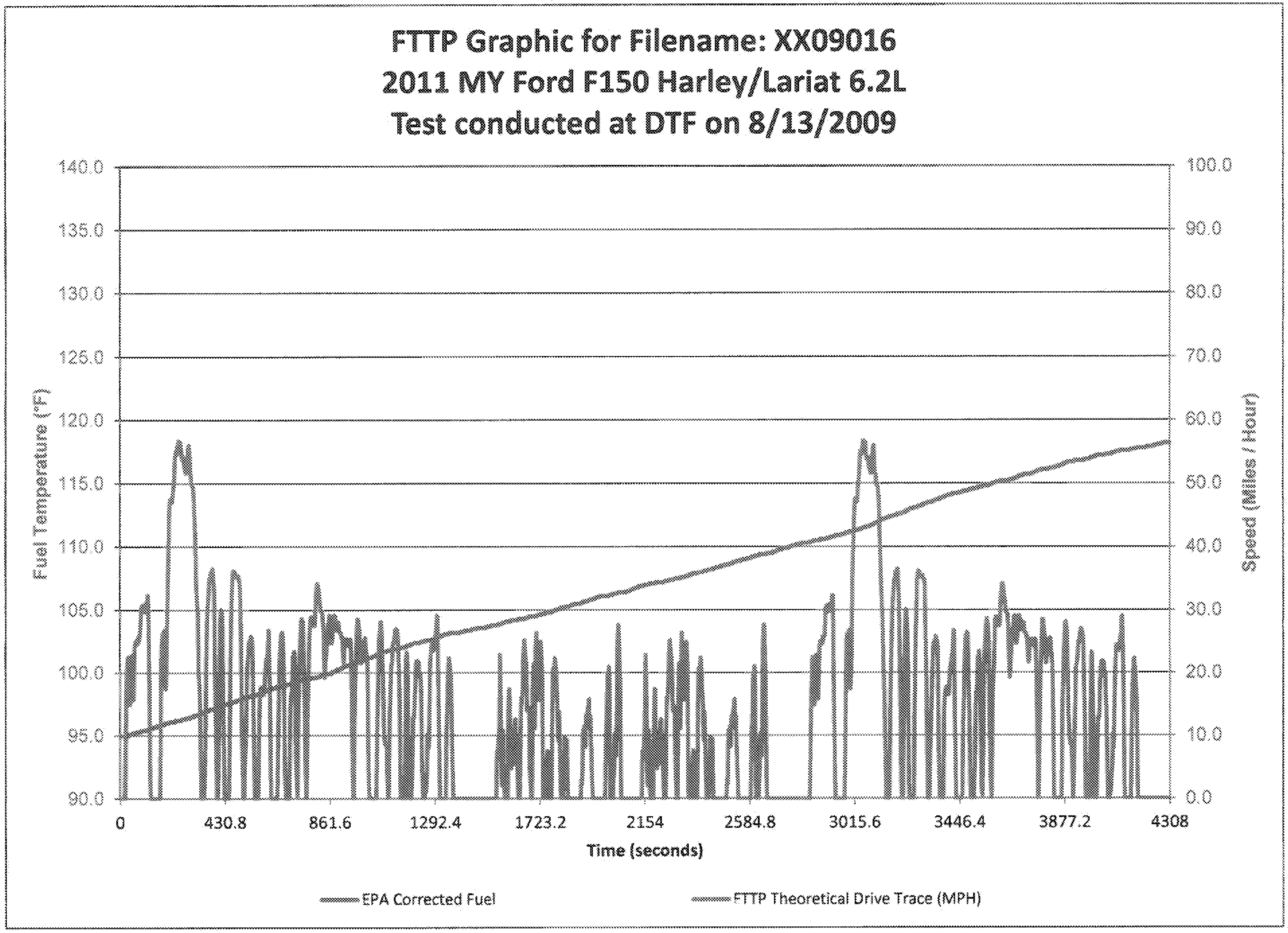

Graphic printed on:
3/2/2012 at 10:05 AM



Filename: XX09012.xls
Tab: FTTP Chart

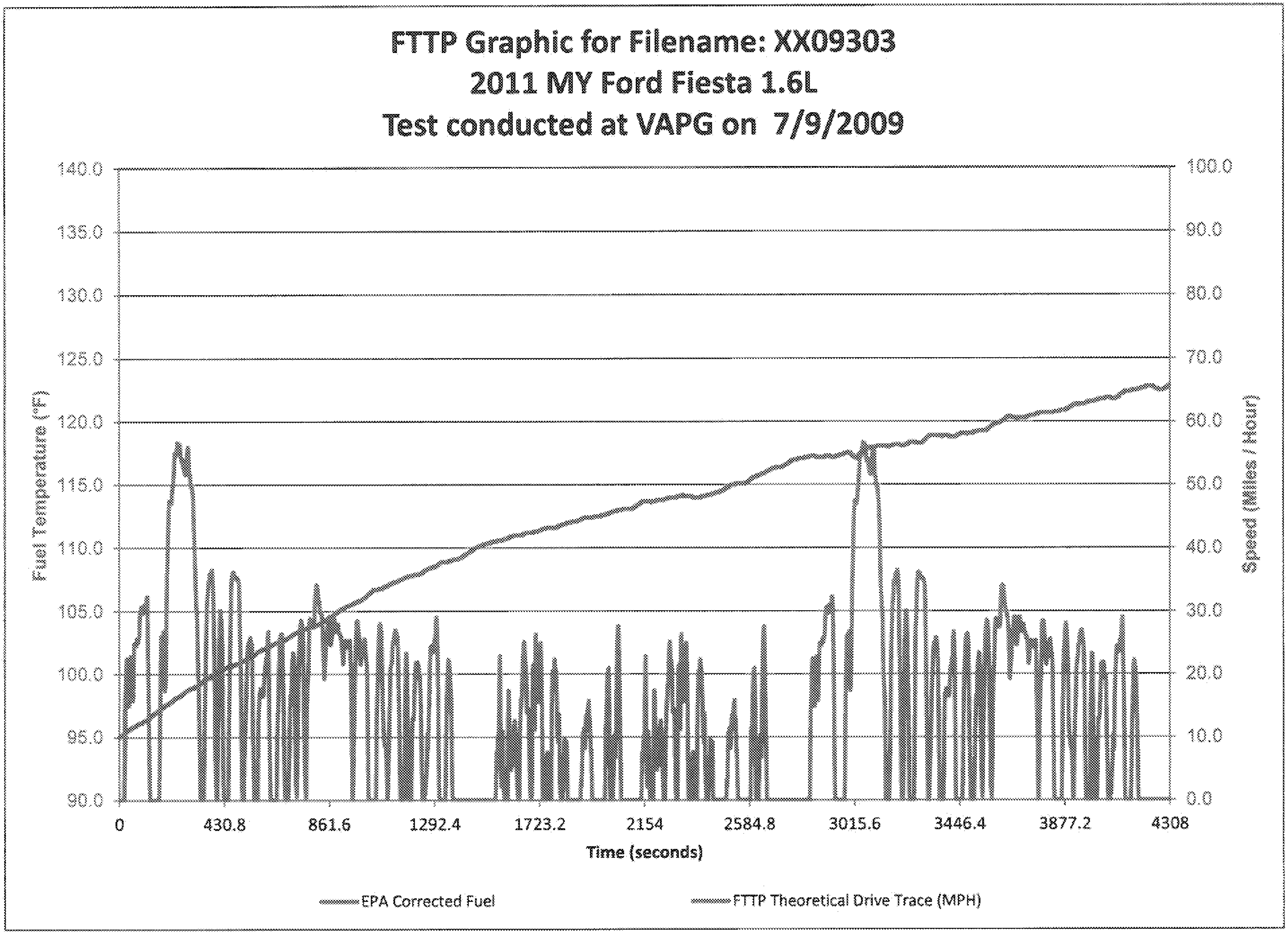
FTTP for Filename: XX09012
(used for DFMXT03.72EE)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.0 |
| 121 | 10.3 | 95.2 |
| 181 | 26.8 | 95.4 |
| 241 | 56.6 | 95.8 |
| 301 | 48.3 | 96.2 |
| 361 | 31.9 | 96.7 |
| 421 | 23.2 | 97.0 |
| 481 | 35.1 | 97.4 |
| 541 | 25.0 | 97.8 |
| 601 | 22.2 | 98.1 |
| 661 | 26.1 | 98.5 |
| 721 | 10.4 | 98.9 |
| 781 | 28.2 | 99.3 |
| 841 | 19.7 | 99.7 |
| 901 | 26.5 | 100.1 |
| 961 | 7.1 | 100.4 |
| 1021 | 2.5 | 100.8 |
| 1081 | 13.5 | 101.1 |
| 1141 | 25.0 | 101.4 |
| 1201 | 11.0 | 101.7 |
| 1261 | 7.2 | 102.1 |
| 1321 | 0.0 | 102.4 |
| 1381 | 0.0 | 102.7 |
| 1441 | 0.0 | 103.0 |
| 1501 | 0.0 | 103.3 |
| 1561 | 21.7 | 103.6 |
| 1621 | 12.1 | 103.9 |
| 1681 | 8.0 | 104.1 |
| 1741 | 0.0 | 104.4 |
| 1801 | 12.8 | 104.7 |
| 1861 | 0.0 | 105.0 |
| 1921 | 14.3 | 105.2 |
| 1981 | 0.0 | 105.6 |
| 2041 | 22.8 | 105.9 |
| 2101 | 0.0 | 106.2 |
| 2161 | 14.5 | 106.4 |
| 2221 | 12.3 | 106.6 |
| 2281 | 3.7 | 106.9 |
| 2341 | 0.0 | 107.2 |
| 2401 | 12.3 | 107.5 |
| 2461 | 0.0 | 107.6 |
| 2521 | 15.1 | 107.8 |
| 2581 | 0.0 | 108.1 |
| 2641 | 26.0 | 108.3 |
| 2701 | 0.0 | 108.7 |
| 2761 | 0.0 | 109.0 |
| 2821 | 0.0 | 109.3 |
| 2881 | 24.6 | 109.6 |
| 2941 | 0.0 | 109.8 |
| 3001 | 19.4 | 110.1 |
| 3061 | 55.9 | 110.4 |
| 3121 | 39.3 | 110.7 |
| 3181 | 34.6 | 111.0 |
| 3241 | 0.0 | 111.1 |
| 3301 | 34.7 | 111.3 |
| 3361 | 8.1 | 111.6 |
| 3421 | 26.3 | 111.8 |
| 3481 | 24.5 | 112.1 |
| 3541 | 5.0 | 112.4 |
| 3601 | 28.3 | 112.7 |
| 3661 | 25.5 | 113.0 |
| 3721 | 25.6 | 113.1 |
| 3781 | 22.5 | 113.4 |
| 3841 | 0.0 | 113.7 |
| 3901 | 8.7 | 114.0 |
| 3961 | 8.9 | 114.3 |
| 4021 | 14.8 | 114.5 |
| 4081 | 12.6 | 114.7 |
| 4141 | 0.0 | 114.9 |
| 4201 | 0.0 | 115.1 |
| 4261 | 0.0 | 115.2 |
| 4308 | 0.0 | 115.3 |


FTTP Graphic for Filename: XX09016
2011 MY Ford F150 Harley/Lariat 6.2L
Test conducted at DTF on 8/13/2009
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

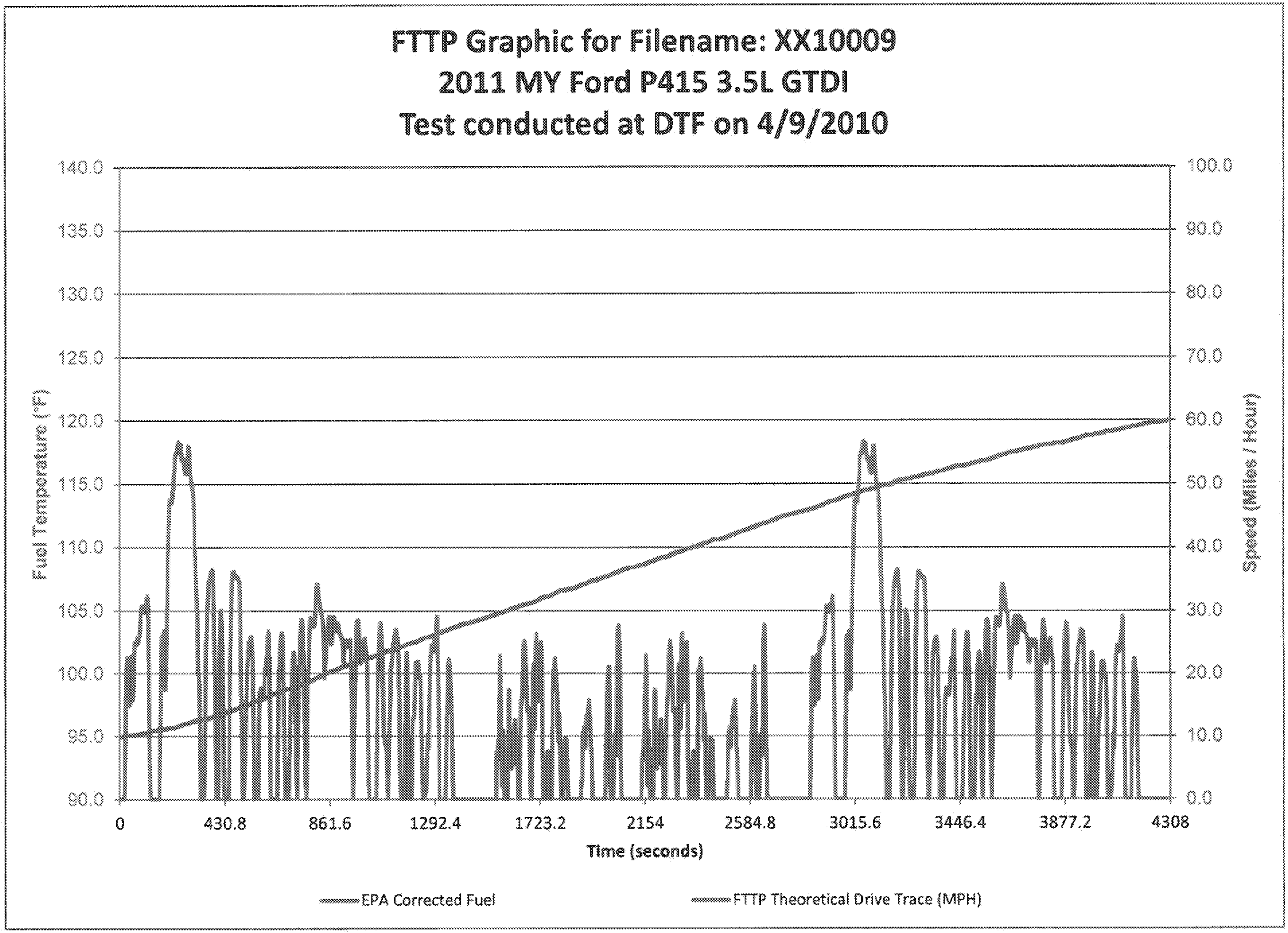
FTTP for Filename: XX09016
(used for DFMXT06.24D2)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.2 |
| 121 | 10.3 | 95.6 |
| 181 | 26.8 | 95.9 |
| 241 | 56.6 | 96.2 |
| 301 | 48.3 | 96.5 |
| 361 | 31.9 | 97.0 |
| 421 | 23.2 | 97.4 |
| 481 | 35.1 | 97.8 |
| 541 | 25.0 | 98.2 |
| 601 | 22.2 | 98.6 |
| 661 | 26.1 | 98.9 |
| 721 | 10.4 | 99.3 |
| 781 | 28.2 | 99.5 |
| 841 | 19.7 | 99.9 |
| 901 | 26.5 | 100.3 |
| 961 | 7.1 | 100.7 |
| 1021 | 2.5 | 101.2 |
| 1081 | 13.5 | 101.7 |
| 1141 | 25.0 | 101.9 |
| 1201 | 11.0 | 102.3 |
| 1261 | 7.2 | 102.6 |
| 1321 | 0.0 | 103.0 |
| 1381 | 0.0 | 103.2 |
| 1441 | 0.0 | 103.4 |
| 1501 | 0.0 | 103.6 |
| 1561 | 21.7 | 103.9 |
| 1621 | 12.1 | 104.2 |
| 1681 | 8.0 | 104.5 |
| 1741 | 0.0 | 104.7 |
| 1801 | 12.8 | 105.1 |
| 1861 | 0.0 | 105.4 |
| 1921 | 14.3 | 105.7 |
| 1981 | 0.0 | 106.1 |
| 2041 | 22.8 | 106.3 |
| 2101 | 0.0 | 106.6 |
| 2161 | 14.5 | 107.0 |
| 2221 | 12.3 | 107.2 |
| 2281 | 3.7 | 107.5 |
| 2341 | 0.0 | 107.8 |
| 2401 | 12.3 | 108.1 |
| 2461 | 0.0 | 108.4 |
| 2521 | 15.1 | 108.8 |
| 2581 | 0.0 | 109.1 |
| 2641 | 26.0 | 109.4 |
| 2701 | 0.0 | 109.7 |
| 2761 | 0.0 | 110.1 |
| 2821 | 0.0 | 110.3 |
| 2881 | 24.6 | 110.6 |
| 2941 | 0.0 | 110.9 |
| 3001 | 19.4 | 111.2 |
| 3061 | 55.9 | 111.5 |
| 3121 | 39.3 | 112.1 |
| 3181 | 34.6 | 112.5 |
| 3241 | 0.0 | 113.0 |
| 3301 | 34.7 | 113.4 |
| 3361 | 8.1 | 113.8 |
| 3421 | 26.3 | 114.2 |
| 3481 | 24.5 | 114.4 |
| 3541 | 5.0 | 114.8 |
| 3601 | 28.3 | 115.1 |
| 3661 | 25.5 | 115.3 |
| 3721 | 25.6 | 115.7 |
| 3781 | 22.5 | 116.1 |
| 3841 | 0.0 | 116.3 |
| 3901 | 8.7 | 116.7 |
| 3961 | 8.9 | 116.9 |
| 4021 | 14.8 | 117.2 |
| 4081 | 12.6 | 117.4 |
| 4141 | 0.0 | 117.6 |
| 4201 | 0.0 | 117.8 |
| 4261 | 0.0 | 118.1 |
| 4308 | 0.0 | 118.2 |


FTTP Graphic for Filename: XX09303
2011 MY Ford Fiesta 1.6L
Test conducted at VAPG on 7/9/2009
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Fuel Temperature (°F)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Speed (Miles / Hour)
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

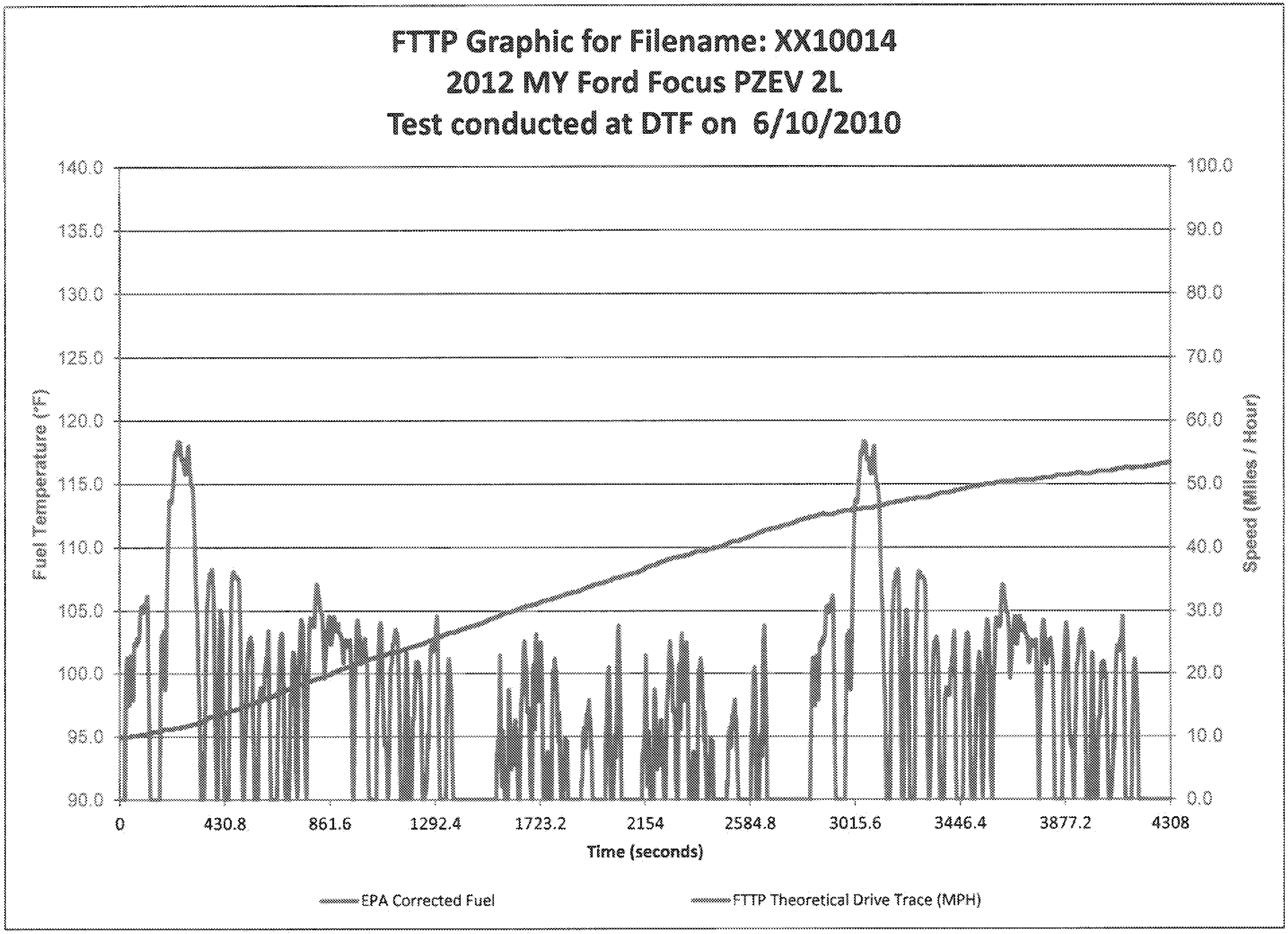
FTTP for Filenamed: XX09303
(used by DFMXV01.6VDB)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.8 |
| 121 | 10.3 | 96.5 |
| 181 | 26.8 | 97.4 |
| 241 | 56.6 | 98.2 |
| 301 | 48.3 | 98.9 |
| 361 | 31.9 | 99.6 |
| 421 | 23.2 | 100.4 |
| 481 | 35.1 | 100.8 |
| 541 | 25.0 | 101.4 |
| 601 | 22.2 | 102.0 |
| 661 | 26.1 | 102.6 |
| 721 | 10.4 | 103.2 |
| 781 | 28.2 | 103.7 |
| 841 | 19.7 | 104.2 |
| 901 | 26.5 | 105.0 |
| 961 | 7.1 | 105.6 |
| 1021 | 2.5 | 106.3 |
| 1081 | 13.5 | 106.9 |
| 1141 | 25.0 | 107.4 |
| 1201 | 11.0 | 107.8 |
| 1261 | 7.2 | 108.3 |
| 1321 | 0.0 | 108.9 |
| 1381 | 0.0 | 109.1 |
| 1441 | 0.0 | 109.7 |
| 1501 | 0.0 | 110.3 |
| 1561 | 21.7 | 110.6 |
| 1621 | 12.1 | 111.0 |
| 1681 | 8.0 | 111.2 |
| 1741 | 0.0 | 111.5 |
| 1801 | 12.8 | 111.7 |
| 1861 | 0.0 | 112.1 |
| 1921 | 14.3 | 112.4 |
| 1981 | 0.0 | 112.6 |
| 2041 | 22.8 | 112.9 |
| 2101 | 0.0 | 113.1 |
| 2161 | 14.5 | 113.7 |
| 2221 | 12.3 | 113.8 |
| 2281 | 3.7 | 114.0 |
| 2341 | 0.0 | 114.1 |
| 2401 | 12.3 | 114.1 |
| 2461 | 0.0 | 114.4 |
| 2521 | 15.1 | 115.0 |
| 2581 | 0.0 | 115.3 |
| 2641 | 26.0 | 115.9 |
| 2701 | 0.0 | 116.4 |
| 2761 | 0.0 | 116.9 |
| 2821 | 0.0 | 117.2 |
| 2881 | 24.6 | 117.2 |
| 2941 | 0.0 | 117.3 |
| 3001 | 19.4 | 117.5 |
| 3061 | 55.9 | 118.0 |
| 3121 | 39.3 | 118.1 |
| 3181 | 34.6 | 118.2 |
| 3241 | 0.0 | 118.3 |
| 3301 | 34.7 | 118.5 |
| 3361 | 8.1 | 118.9 |
| 3421 | 26.3 | 118.8 |
| 3481 | 24.5 | 119.1 |
| 3541 | 5.0 | 119.3 |
| 3601 | 28.3 | 119.9 |
| 3661 | 25.5 | 120.3 |
| 3721 | 25.6 | 120.3 |
| 3781 | 22.5 | 120.7 |
| 3841 | 0.0 | 120.8 |
| 3901 | 8.7 | 121.2 |
| 3961 | 8.9 | 121.4 |
| 4021 | 14.8 | 121.8 |
| 4081 | 12.6 | 121.8 |
| 4141 | 0.0 | 122.4 |
| 4201 | 0.0 | 122.7 |
| 4261 | 0.0 | 122.5 |
| 4308 | 0.0 | 122.9 |


FTTP Graphic for Filename: XX10009
2011 MY Ford P415 3.5L GTDI
Test conducted at DTF on 4/9/2010
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

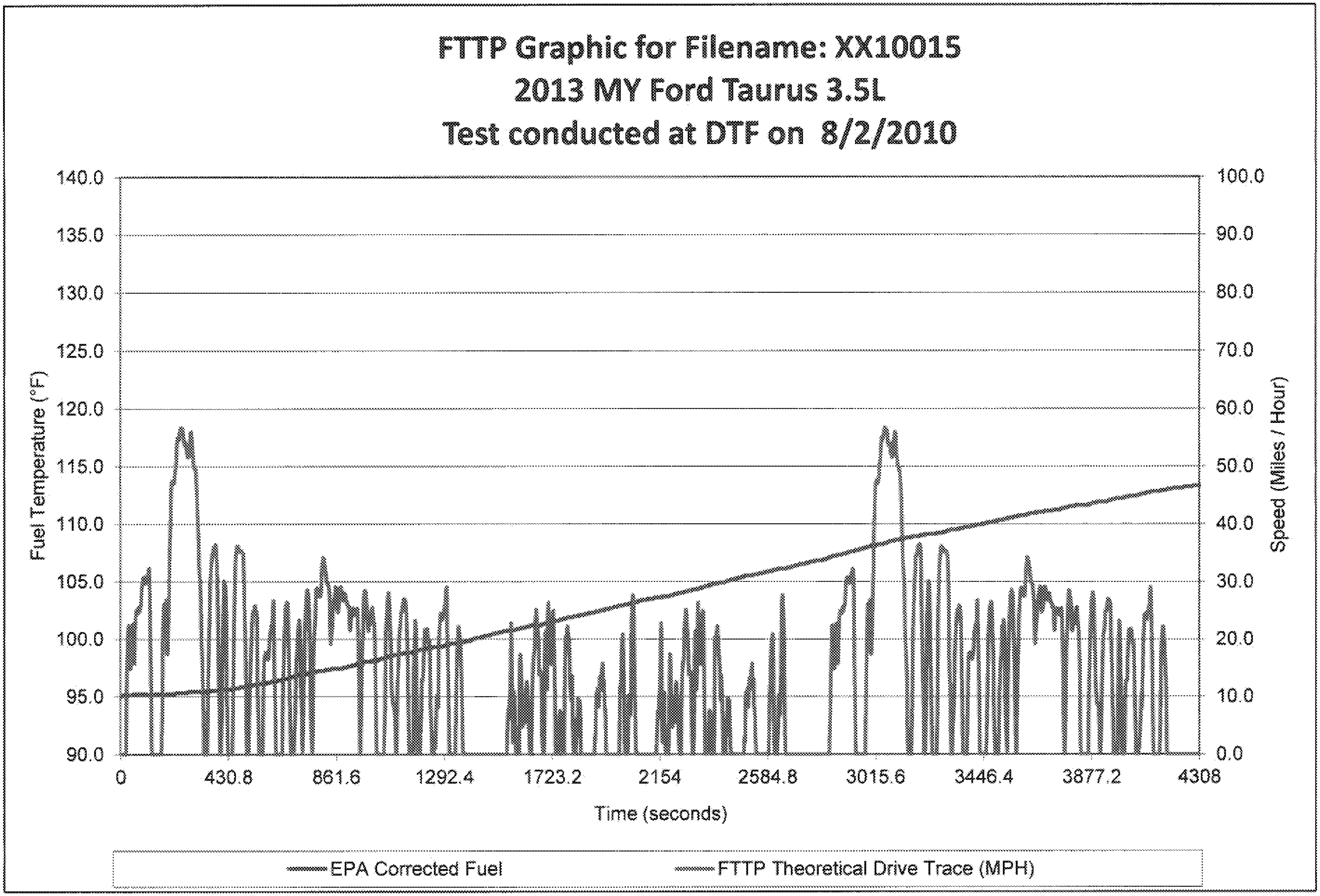
FTTP for Filename: XX10009
(used for DFMXT03.54DX)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.1 |
| 121 | 10.3 | 95.4 |
| 181 | 26.8 | 95.6 |
| 241 | 56.6 | 95.8 |
| 301 | 48.3 | 96.2 |
| 361 | 31.9 | 96.4 |
| 421 | 23.2 | 96.8 |
| 481 | 35.1 | 97.2 |
| 541 | 25.0 | 97.7 |
| 601 | 22.2 | 98.1 |
| 661 | 26.1 | 98.5 |
| 721 | 10.4 | 99.0 |
| 781 | 28.2 | 99.4 |
| 841 | 19.7 | 99.9 |
| 901 | 26.5 | 100.4 |
| 961 | 7.1 | 100.8 |
| 1021 | 2.5 | 101.3 |
| 1081 | 13.5 | 101.7 |
| 1141 | 25.0 | 102.0 |
| 1201 | 11.0 | 102.5 |
| 1261 | 7.2 | 102.9 |
| 1321 | 0.0 | 103.3 |
| 1381 | 0.0 | 103.7 |
| 1441 | 0.0 | 104.1 |
| 1501 | 0.0 | 104.4 |
| 1561 | 21.7 | 104.8 |
| 1621 | 12.1 | 105.2 |
| 1681 | 8.0 | 105.6 |
| 1741 | 0.0 | 106.1 |
| 1801 | 12.8 | 106.5 |
| 1861 | 0.0 | 106.8 |
| 1921 | 14.3 | 107.2 |
| 1981 | 0.0 | 107.6 |
| 2041 | 22.8 | 108.0 |
| 2101 | 0.0 | 108.4 |
| 2161 | 14.5 | 108.7 |
| 2221 | 12.3 | 109.2 |
| 2281 | 3.7 | 109.6 |
| 2341 | 0.0 | 109.9 |
| 2401 | 12.3 | 110.3 |
| 2461 | 0.0 | 110.6 |
| 2521 | 15.1 | 111.0 |
| 2581 | 0.0 | 111.4 |
| 2641 | 26.0 | 111.9 |
| 2701 | 0.0 | 112.3 |
| 2761 | 0.0 | 112.6 |
| 2821 | 0.0 | 112.9 |
| 2881 | 24.6 | 113.3 |
| 2941 | 0.0 | 113.7 |
| 3001 | 19.4 | 114.1 |
| 3061 | 55.9 | 114.5 |
| 3121 | 39.3 | 114.8 |
| 3181 | 34.6 | 115.1 |
| 3241 | 0.0 | 115.4 |
| 3301 | 34.7 | 115.7 |
| 3361 | 8.1 | 116.0 |
| 3421 | 26.3 | 116.3 |
| 3481 | 24.5 | 116.5 |
| 3541 | 5.0 | 116.8 |
| 3601 | 28.3 | 117.2 |
| 3661 | 25.5 | 117.5 |
| 3721 | 25.6 | 117.8 |
| 3781 | 22.5 | 118.0 |
| 3841 | 0.0 | 118.2 |
| 3901 | 8.7 | 118.4 |
| 3961 | 8.9 | 118.8 |
| 4021 | 14.8 | 118.9 |
| 4081 | 12.6 | 119.2 |
| 4141 | 0.0 | 119.4 |
| 4201 | 0.0 | 119.7 |
| 4261 | 0.0 | 119.8 |
| 4308 | 0.0 | 120.0 |


FTTP Graphic for Filename: XX10014
2012 MY Ford Focus PZEV 2L
Test conducted at DTF on 6/10/2010
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

FTTP for Filename: XX10014
(used for DFMXV02.0VZ2)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.1 |
| 121 | 10.3 | 95.3 |
| 181 | 26.8 | 95.6 |
| 241 | 56.6 | 95.7 |
| 301 | 48.3 | 96.0 |
| 361 | 31.9 | 96.5 |
| 421 | 23.2 | 96.8 |
| 481 | 35.1 | 97.2 |
| 541 | 25.0 | 97.6 |
| 601 | 22.2 | 98.0 |
| 661 | 26.1 | 98.5 |
| 721 | 10.4 | 98.9 |
| 781 | 28.2 | 99.4 |
| 841 | 19.7 | 99.8 |
| 901 | 26.5 | 100.3 |
| 961 | 7.1 | 100.7 |
| 1021 | 2.5 | 101.1 |
| 1081 | 13.5 | 101.4 |
| 1141 | 25.0 | 101.8 |
| 1201 | 11.0 | 102.2 |
| 1261 | 7.2 | 102.6 |
| 1321 | 0.0 | 103.0 |
| 1381 | 0.0 | 103.4 |
| 1441 | 0.0 | 103.8 |
| 1501 | 0.0 | 104.2 |
| 1561 | 21.7 | 104.6 |
| 1621 | 12.1 | 105.0 |
| 1681 | 8.0 | 105.4 |
| 1741 | 0.0 | 105.8 |
| 1801 | 12.8 | 106.1 |
| 1861 | 0.0 | 106.5 |
| 1921 | 14.3 | 106.9 |
| 1981 | 0.0 | 107.2 |
| 2041 | 22.8 | 107.6 |
| 2101 | 0.0 | 107.9 |
| 2161 | 14.5 | 108.4 |
| 2221 | 12.3 | 108.8 |
| 2281 | 3.7 | 109.2 |
| 2341 | 0.0 | 109.5 |
| 2401 | 12.3 | 109.7 |
| 2461 | 0.0 | 110.0 |
| 2521 | 15.1 | 110.5 |
| 2581 | 0.0 | 110.8 |
| 2641 | 26.0 | 111.3 |
| 2701 | 0.0 | 111.6 |
| 2761 | 0.0 | 111.9 |
| 2821 | 0.0 | 112.3 |
| 2881 | 24.6 | 112.6 |
| 2941 | 0.0 | 112.7 |
| 3001 | 19.4 | 112.9 |
| 3061 | 55.9 | 113.1 |
| 3121 | 39.3 | 113.3 |
| 3181 | 34.6 | 113.6 |
| 3241 | 0.0 | 113.8 |
| 3301 | 34.7 | 113.9 |
| 3361 | 8.1 | 114.2 |
| 3421 | 26.3 | 114.4 |
| 3481 | 24.5 | 114.7 |
| 3541 | 5.0 | 114.9 |
| 3601 | 28.3 | 115.1 |
| 3661 | 25.5 | 115.2 |
| 3721 | 25.6 | 115.3 |
| 3781 | 22.5 | 115.5 |
| 3841 | 0.0 | 115.6 |
| 3901 | 8.7 | 115.8 |
| 3961 | 8.9 | 115.8 |
| 4021 | 14.8 | 116.0 |
| 4081 | 12.6 | 116.1 |
| 4141 | 0.0 | 116.3 |
| 4201 | 0.0 | 116.3 |
| 4261 | 0.0 | 116.5 |
| 4308 | 0.0 | 116.7 |



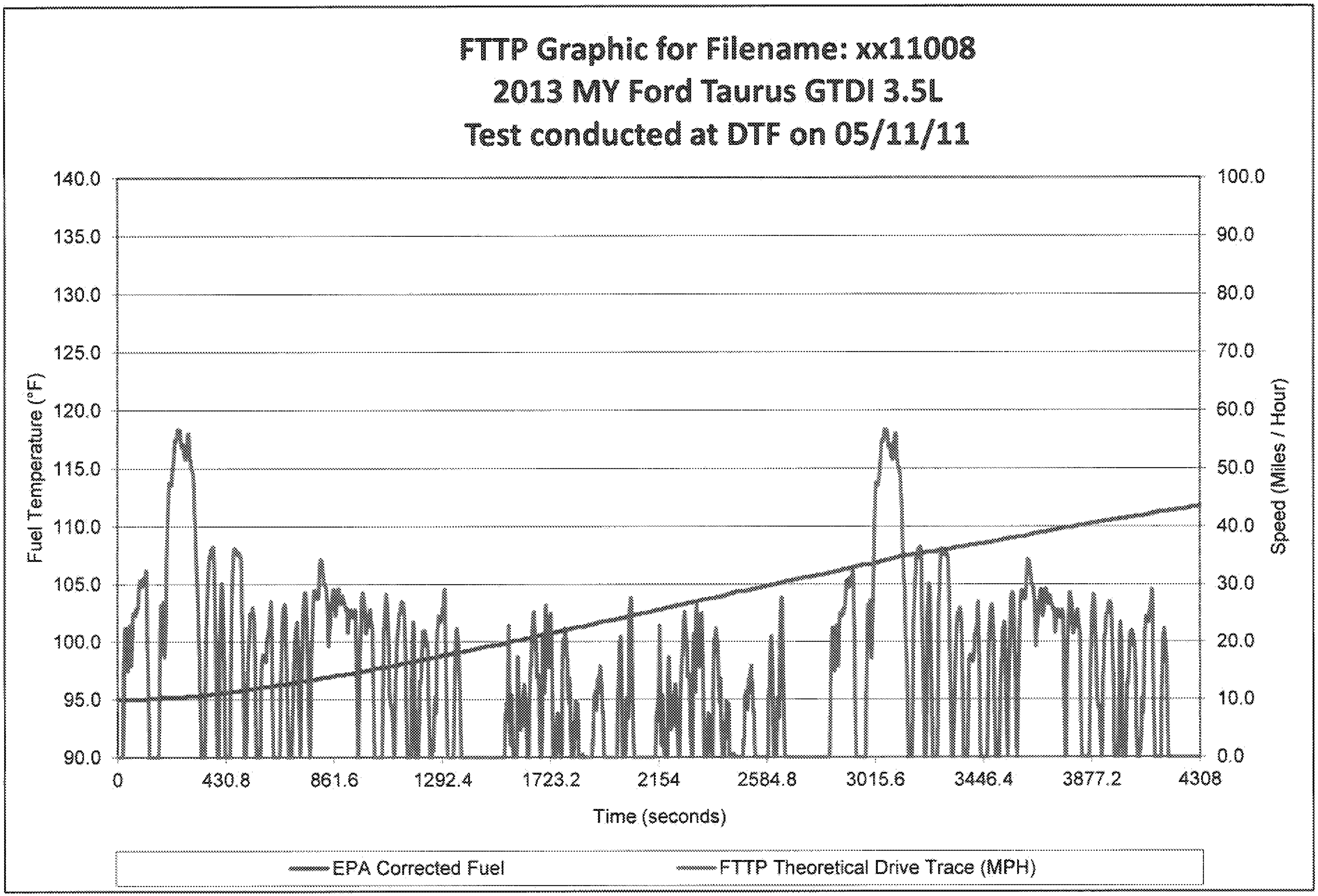

Graphic printed on:
3/2/2012 at 10:12 AM



Filename: XX10015.xls
Tab: FTTP Chart

FTTP for Filename: XX10015
(used for DFMXV03.5VEA, DFMXT03.73DM)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.2 |
| 121 | 10.3 | 95.1 |
| 181 | 26.8 | 95.2 |
| 241 | 56.6 | 95.3 |
| 301 | 48.3 | 95.4 |
| 361 | 31.9 | 95.5 |
| 421 | 23.2 | 95.6 |
| 481 | 35.1 | 95.8 |
| 541 | 25.0 | 96.0 |
| 601 | 22.2 | 96.3 |
| 661 | 26.1 | 96.5 |
| 721 | 10.4 | 96.9 |
| 781 | 28.2 | 97.1 |
| 841 | 19.7 | 97.4 |
| 901 | 26.5 | 97.5 |
| 961 | 7.1 | 97.9 |
| 1021 | 2.5 | 98.1 |
| 1081 | 13.5 | 98.5 |
| 1141 | 25.0 | 98.8 |
| 1201 | 11.0 | 99.1 |
| 1261 | 7.2 | 99.3 |
| 1321 | 0.0 | 99.6 |
| 1381 | 0.0 | 99.8 |
| 1441 | 0.0 | 100.2 |
| 1501 | 0.0 | 100.5 |
| 1561 | 21.7 | 100.8 |
| 1621 | 12.1 | 101.1 |
| 1681 | 8.0 | 101.2 |
| 1741 | 0.0 | 101.6 |
| 1801 | 12.8 | 101.9 |
| 1861 | 0.0 | 102.2 |
| 1921 | 14.3 | 102.5 |
| 1981 | 0.0 | 102.8 |
| 2041 | 22.8 | 103.1 |
| 2101 | 0.0 | 103.4 |
| 2161 | 14.5 | 103.7 |
| 2221 | 12.3 | 103.9 |
| 2281 | 3.7 | 104.2 |
| 2341 | 0.0 | 104.6 |
| 2401 | 12.3 | 104.9 |
| 2461 | 0.0 | 105.3 |
| 2521 | 15.1 | 105.5 |
| 2581 | 0.0 | 105.8 |
| 2641 | 26.0 | 106.1 |
| 2701 | 0.0 | 106.4 |
| 2761 | 0.0 | 106.7 |
| 2821 | 0.0 | 107.0 |
| 2881 | 24.6 | 107.4 |
| 2941 | 0.0 | 107.7 |
| 3001 | 19.4 | 108.1 |
| 3061 | 55.9 | 108.4 |
| 3121 | 39.3 | 108.7 |
| 3181 | 34.6 | 108.9 |
| 3241 | 0.0 | 109.1 |
| 3301 | 34.7 | 109.4 |
| 3361 | 6.1 | 109.6 |
| 3421 | 26.3 | 109.9 |
| 3481 | 24.5 | 110.1 |
| 3541 | 5.0 | 110.4 |
| 3601 | 28.3 | 110.7 |
| 3661 | 25.5 | 110.9 |
| 3721 | 25.6 | 111.1 |
| 3781 | 22.5 | 111.4 |
| 3841 | 0.0 | 111.6 |
| 3901 | 6.7 | 111.9 |
| 3961 | 8.9 | 112.1 |
| 4021 | 14.8 | 112.3 |
| 4081 | 12.6 | 112.6 |
| 4141 | 0.0 | 112.8 |
| 4201 | 0.0 | 113.1 |
| 4261 | 0.0 | 113.2 |
| 4308 | 0.0 | 113.3 |



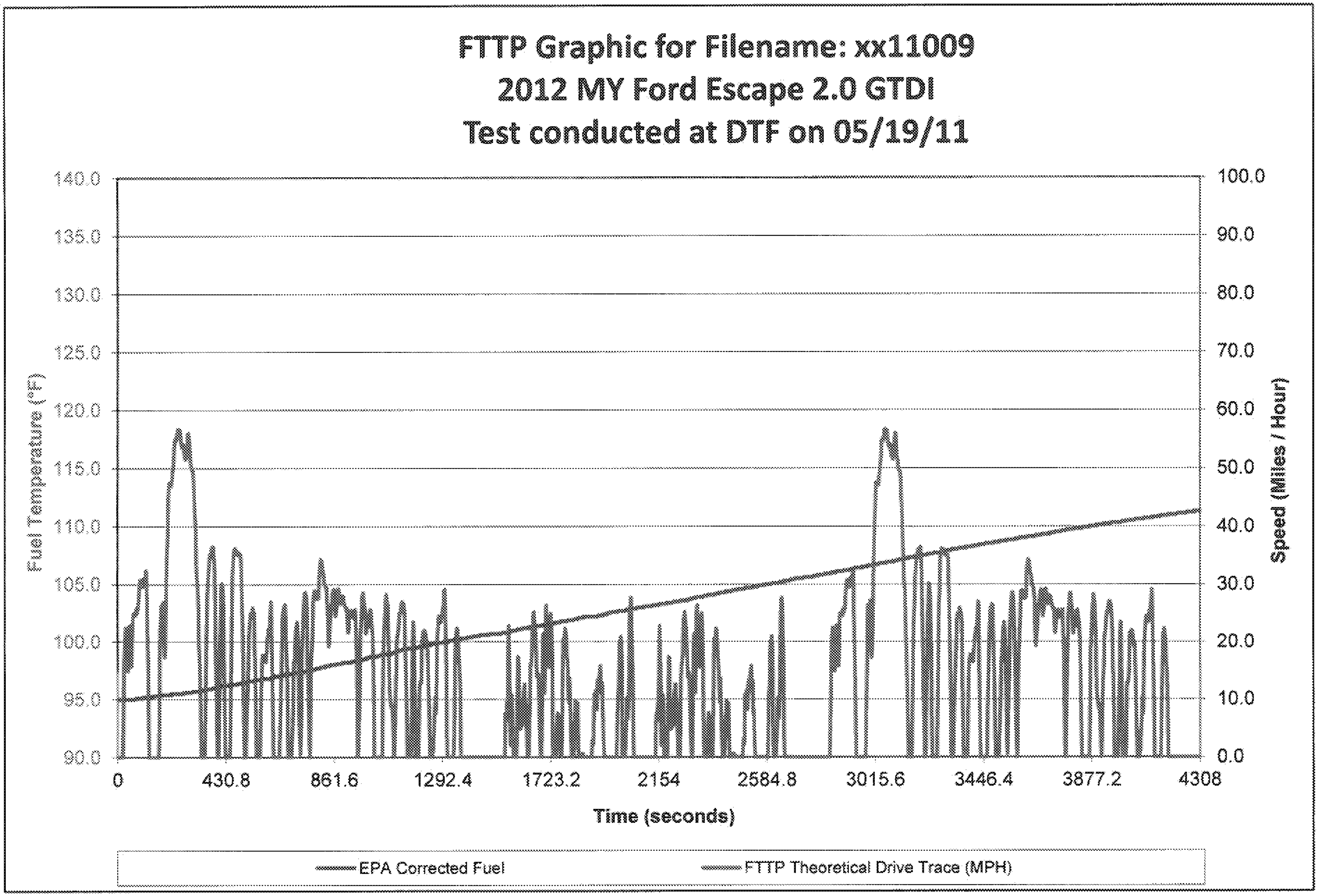

Graphic printed on:
3/2/2012 at 10:17 AM



Filename: xx11008.xls
Tab: FTTP Chart

FTTP for Filename: xx11008
(used for DFMXT02.02EC)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.5 | 95.0 |
| 121 | 12.8 | 95.1 |
| 181 | 26.9 | 95.2 |
| 241 | 56.7 | 95.2 |
| 301 | 48.6 | 95.3 |
| 361 | 31.6 | 95.4 |
| 421 | 25.0 | 95.6 |
| 481 | 35.0 | 95.7 |
| 541 | 25.0 | 95.9 |
| 601 | 22.0 | 96.1 |
| 661 | 26.0 | 96.3 |
| 721 | 12.0 | 96.5 |
| 781 | 28.0 | 96.7 |
| 841 | 19.2 | 96.9 |
| 901 | 26.6 | 97.1 |
| 961 | 5.3 | 97.4 |
| 1021 | 4.3 | 97.6 |
| 1081 | 15.0 | 97.8 |
| 1141 | 25.5 | 98.1 |
| 1201 | 9.8 | 98.4 |
| 1261 | 6.3 | 98.6 |
| 1321 | 0.0 | 98.9 |
| 1381 | 0.0 | 99.1 |
| 1441 | 0.0 | 99.4 |
| 1501 | 0.0 | 99.7 |
| 1561 | 10.2 | 100.0 |
| 1621 | 10.6 | 100.2 |
| 1681 | 2.9 | 100.6 |
| 1741 | 0.0 | 100.8 |
| 1801 | 10.4 | 101.1 |
| 1861 | 0.0 | 101.4 |
| 1921 | 15.3 | 101.7 |
| 1981 | 0.0 | 101.9 |
| 2041 | 26.7 | 102.3 |
| 2101 | 0.0 | 102.5 |
| 2161 | 14.5 | 102.8 |
| 2221 | 12.3 | 103.1 |
| 2281 | 3.7 | 103.4 |
| 2341 | 0.0 | 103.7 |
| 2401 | 12.3 | 103.9 |
| 2461 | 0.1 | 104.3 |
| 2521 | 15.1 | 104.5 |
| 2581 | 0.0 | 104.8 |
| 2641 | 26.0 | 105.1 |
| 2701 | 0.0 | 105.4 |
| 2761 | 0.0 | 105.6 |
| 2821 | 0.0 | 105.9 |
| 2881 | 24.7 | 106.2 |
| 2941 | 0.0 | 106.5 |
| 3001 | 17.7 | 106.7 |
| 3061 | 56.5 | 107.1 |
| 3121 | 43.8 | 107.4 |
| 3181 | 34.6 | 107.6 |
| 3241 | 8.5 | 107.8 |
| 3301 | 35.0 | 108.0 |
| 3361 | 19.8 | 108.2 |
| 3421 | 22.7 | 108.4 |
| 3481 | 26.5 | 108.6 |
| 3541 | 2.1 | 108.9 |
| 3601 | 28.8 | 109.1 |
| 3661 | 22.6 | 109.4 |
| 3721 | 26.2 | 109.7 |
| 3781 | 18.6 | 109.9 |
| 3841 | 0.0 | 110.1 |
| 3901 | 9.5 | 110.4 |
| 3961 | 17.5 | 110.6 |
| 4021 | 12.8 | 110.8 |
| 4081 | 8.5 | 110.9 |
| 4141 | 0.0 | 111.3 |
| 4201 | 0.0 | 111.4 |
| 4261 | 0.0 | 111.6 |
| 4308 | 0.0 | 111.8 |



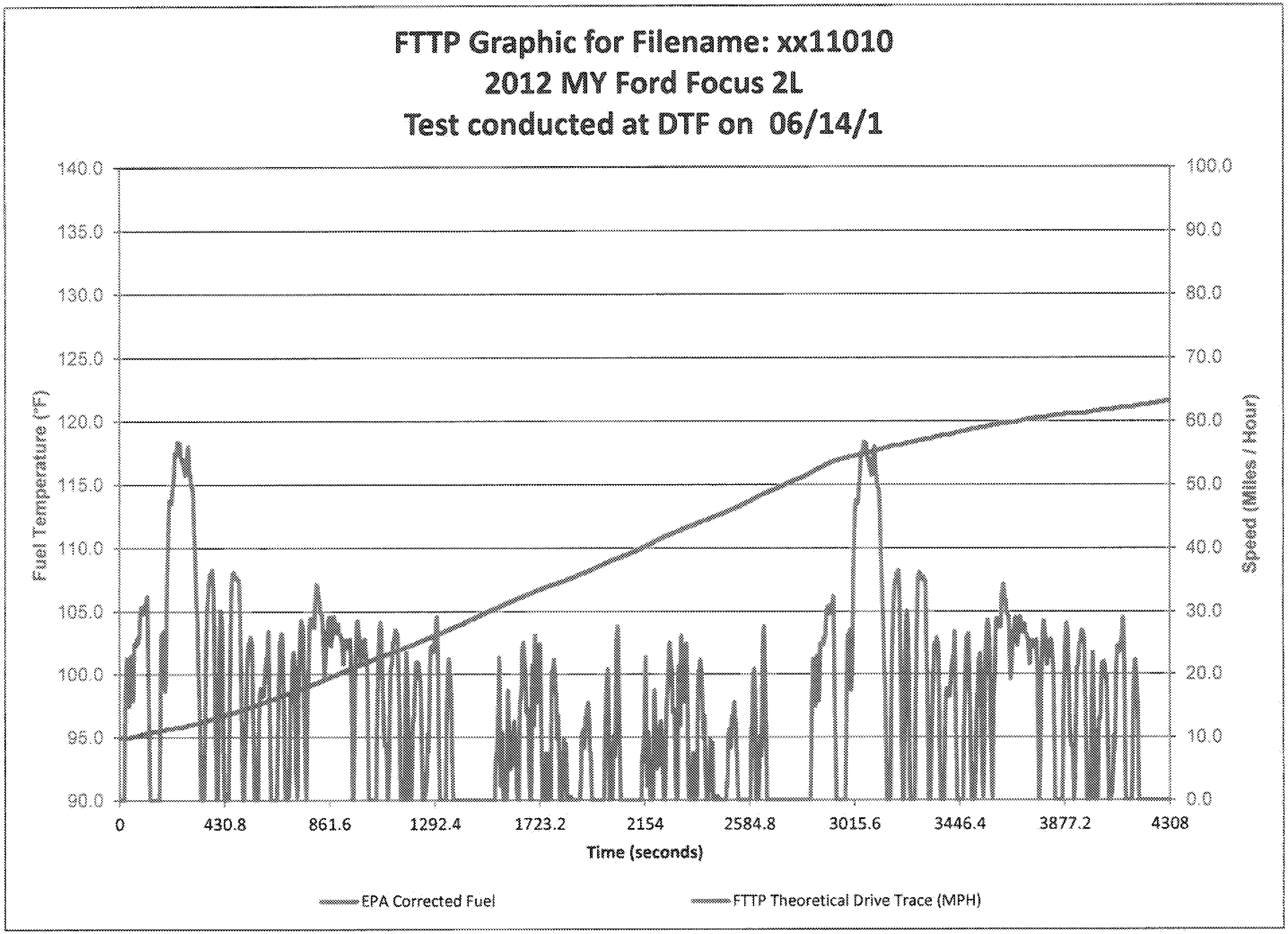

Graphic printed on:
3/2/2012 at 10:20 AM



Filename: xx11009.xls
Tab: FTTP Chart

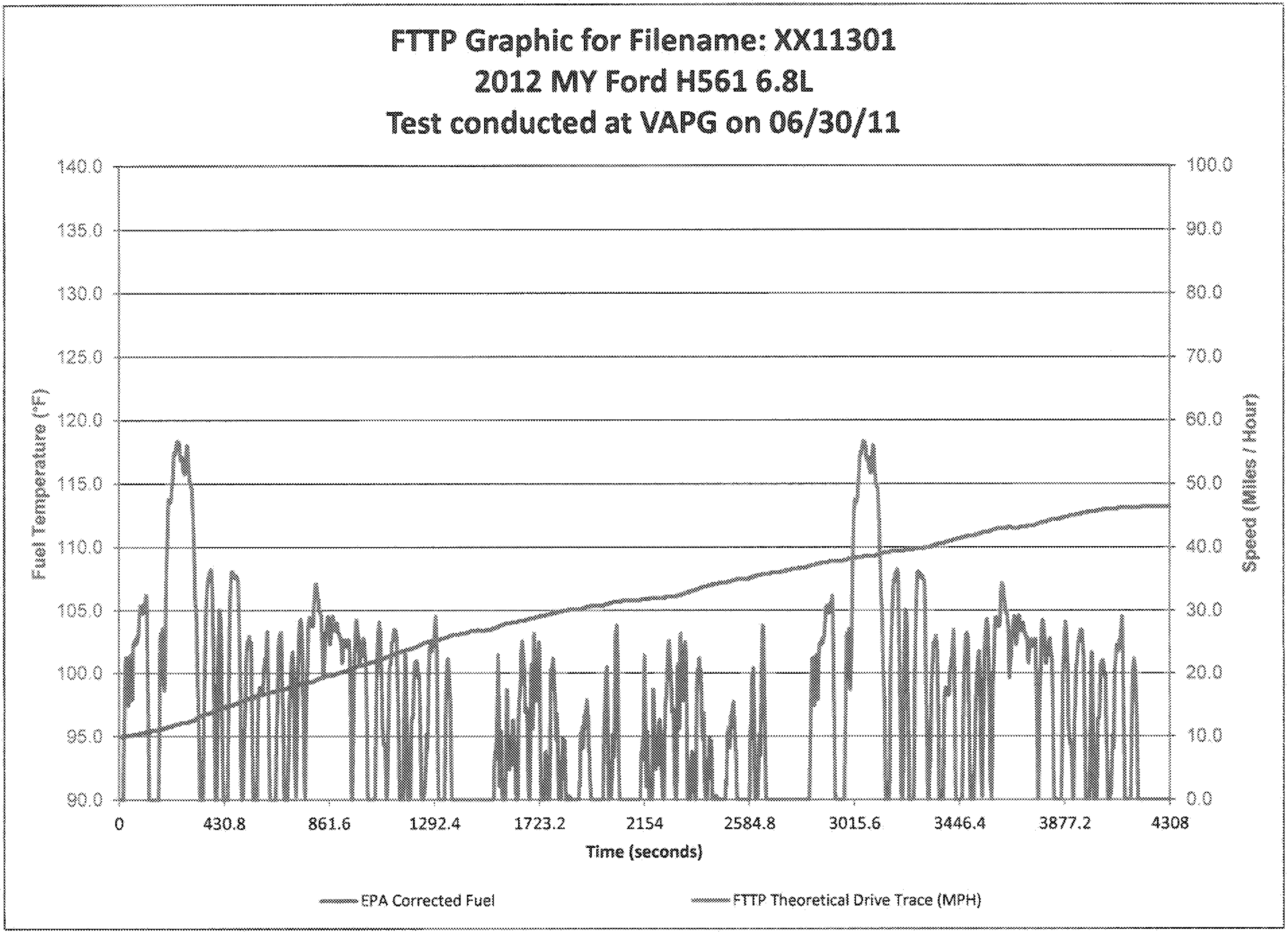
FTTP for Filename: XX11009
(used by DFMXV02.5VEX, DFMXT02.52ET, DFMXT02.02E1, DFMXT01.62E9)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.5 | 95.0 |
| 121 | 12.8 | 95.2 |
| 181 | 26.9 | 95.4 |
| 241 | 56.7 | 95.5 |
| 301 | 48.6 | 95.7 |
| 361 | 31.6 | 95.9 |
| 421 | 25.0 | 96.2 |
| 481 | 35.0 | 96.4 |
| 541 | 25.0 | 96.6 |
| 601 | 22.0 | 96.8 |
| 661 | 26.0 | 97.1 |
| 721 | 12.0 | 97.3 |
| 781 | 28.0 | 97.6 |
| 841 | 19.2 | 97.9 |
| 901 | 26.6 | 98.2 |
| 961 | 5.3 | 98.4 |
| 1021 | 4.3 | 98.7 |
| 1081 | 15.0 | 98.9 |
| 1141 | 25.5 | 99.3 |
| 1201 | 9.8 | 99.6 |
| 1261 | 6.3 | 99.8 |
| 1321 | 0.0 | 100.1 |
| 1381 | 0.0 | 100.3 |
| 1441 | 0.0 | 100.5 |
| 1501 | 0.0 | 100.7 |
| 1561 | 10.2 | 100.9 |
| 1621 | 10.6 | 101.2 |
| 1681 | 2.9 | 101.4 |
| 1741 | 0.0 | 101.6 |
| 1801 | 10.4 | 101.9 |
| 1861 | 0.0 | 102.2 |
| 1921 | 15.3 | 102.3 |
| 1981 | 0.0 | 102.6 |
| 2041 | 26.7 | 102.8 |
| 2101 | 0.0 | 103.1 |
| 2161 | 14.5 | 103.3 |
| 2221 | 12.3 | 103.5 |
| 2281 | 3.7 | 103.7 |
| 2341 | 0.0 | 104.0 |
| 2401 | 12.3 | 104.3 |
| 2461 | 0.1 | 104.5 |
| 2521 | 15.1 | 104.7 |
| 2581 | 0.0 | 105.0 |
| 2641 | 26.0 | 105.2 |
| 2701 | 0.0 | 105.5 |
| 2761 | 0.0 | 105.6 |
| 2821 | 0.0 | 105.9 |
| 2881 | 24.7 | 106.1 |
| 2941 | 0.0 | 106.4 |
| 3001 | 17.7 | 106.6 |
| 3061 | 56.5 | 106.8 |
| 3121 | 43.6 | 107.1 |
| 3181 | 34.6 | 107.4 |
| 3241 | 8.5 | 107.6 |
| 3301 | 35.0 | 107.9 |
| 3361 | 19.8 | 108.1 |
| 3421 | 22.7 | 108.3 |
| 3481 | 26.5 | 108.5 |
| 3541 | 2.1 | 108.8 |
| 3601 | 28.8 | 109.0 |
| 3661 | 22.6 | 109.2 |
| 3721 | 26.2 | 109.4 |
| 3781 | 18.6 | 109.7 |
| 3841 | 0.0 | 109.9 |
| 3901 | 9.5 | 110.1 |
| 3961 | 17.5 | 110.3 |
| 4021 | 12.8 | 110.5 |
| 4081 | 8.5 | 110.6 |
| 4141 | 0.0 | 110.8 |
| 4201 | 0.0 | 111.0 |
| 4261 | 0.0 | 111.2 |
| 4308 | 0.0 | 111.3 |


FTTP Graphic for Filename: xx11010
2012 MY Ford Focus 2L
Test conducted at DTF on 06/14/1
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

FTTP for Filename: XX11010
(used for DFMXV02.0VD2, DFMXV02.0VER)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 1 | 0.0 | 95.0 |
| 61 | 24.8 | 95.1 |
| 121 | 9.5 | 95.4 |
| 181 | 26.6 | 95.6 |
| 241 | 56.5 | 95.8 |
| 301 | 48.2 | 96.0 |
| 361 | 31.4 | 96.4 |
| 421 | 25.6 | 96.7 |
| 481 | 35.0 | 97.0 |
| 541 | 25.0 | 97.4 |
| 601 | 21.9 | 97.8 |
| 661 | 25.9 | 98.3 |
| 721 | 12.6 | 98.6 |
| 781 | 27.9 | 99.1 |
| 841 | 19.2 | 99.6 |
| 901 | 26.6 | 100.1 |
| 961 | 5.3 | 100.6 |
| 1021 | 4.3 | 101.0 |
| 1081 | 15.0 | 101.5 |
| 1141 | 25.5 | 101.9 |
| 1201 | 9.8 | 102.4 |
| 1261 | 6.3 | 102.9 |
| 1321 | 0.0 | 103.3 |
| 1381 | 0.0 | 103.8 |
| 1441 | 0.0 | 104.4 |
| 1501 | 0.0 | 104.9 |
| 1561 | 9.3 | 105.4 |
| 1621 | 10.5 | 105.9 |
| 1681 | 2.6 | 106.4 |
| 1741 | 0.0 | 106.9 |
| 1801 | 10.0 | 107.3 |
| 1861 | 0.0 | 107.7 |
| 1921 | 15.4 | 108.2 |
| 1981 | 0.0 | 108.7 |
| 2041 | 26.8 | 109.2 |
| 2101 | 0.0 | 109.6 |
| 2161 | 13.6 | 110.2 |
| 2221 | 12.0 | 110.8 |
| 2281 | 3.5 | 111.3 |
| 2341 | 0.0 | 111.7 |
| 2401 | 11.9 | 112.2 |
| 2461 | 0.1 | 112.6 |
| 2521 | 15.1 | 113.1 |
| 2581 | 0.0 | 113.7 |
| 2641 | 26.1 | 114.3 |
| 2701 | 0.0 | 114.7 |
| 2761 | 0.0 | 115.3 |
| 2821 | 0.0 | 115.8 |
| 2881 | 24.7 | 116.4 |
| 2941 | 0.0 | 116.9 |
| 3001 | 17.6 | 117.2 |
| 3061 | 56.5 | 117.5 |
| 3121 | 43.6 | 117.8 |
| 3181 | 34.7 | 118.1 |
| 3241 | 7.8 | 118.3 |
| 3301 | 35.0 | 118.5 |
| 3361 | 19.1 | 118.8 |
| 3421 | 22.9 | 119.0 |
| 3481 | 26.5 | 119.3 |
| 3541 | 1.8 | 119.5 |
| 3601 | 28.7 | 119.7 |
| 3661 | 22.7 | 119.9 |
| 3721 | 26.2 | 120.1 |
| 3781 | 18.9 | 120.3 |
| 3841 | 0.0 | 120.5 |
| 3901 | 9.4 | 120.6 |
| 3961 | 17.2 | 120.6 |
| 4021 | 12.9 | 120.8 |
| 4081 | 8.3 | 121.0 |
| 4141 | 0.0 | 121.1 |
| 4201 | 0.0 | 121.3 |
| 4261 | 0.0 | 121.5 |
| 4308 | 0.0 | 121.6 |


FTTP Graphic for Filename: XX11301
2012 MY Ford H561 6.8L
Test conducted at VAPG on 06/30/11
Fuel Temperature (°F)
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
Speed (Miles / Hour)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
430.8
861.6
1292.4
1723.2
2154
2584.8
3015.6
3446.4
3877.2
4308
Time (seconds)
EPA Corrected Fuel
FTTP Theoretical Drive Trace (MPH)

FTTP for Filename: XX11301
(used for DFMXE06.8BW5)

| Time Sec | Trace Speed MPH | EPA Fuel Temp °F |
|---|---|---|
| 0 | 0.0 | 95.0 |
| 60 | 24.9 | 95.2 |
| 120 | 8.8 | 95.4 |
| 180 | 26.5 | 95.6 |
| 240 | 56.5 | 96.0 |
| 300 | 48.1 | 96.3 |
| 360 | 32.2 | 96.8 |
| 420 | 21.0 | 97.3 |
| 480 | 35.1 | 97.6 |
| 540 | 25.0 | 98.0 |
| 600 | 22.4 | 98.4 |
| 660 | 26.1 | 98.7 |
| 720 | 7.9 | 99.0 |
| 780 | 28.7 | 99.3 |
| 840 | 20.6 | 99.7 |
| 900 | 26.5 | 100.0 |
| 960 | 10.6 | 100.4 |
| 1020 | 0.2 | 100.8 |
| 1080 | 11.3 | 101.1 |
| 1140 | 23.7 | 101.6 |
| 1200 | 12.7 | 102.0 |
| 1260 | 9.6 | 102.5 |
| 1320 | 0.0 | 102.8 |
| 1380 | 0.0 | 103.1 |
| 1440 | 0.0 | 103.4 |
| 1500 | 0.0 | 103.4 |
| 1560 | 2.5 | 103.8 |
| 1620 | 9.4 | 104.1 |
| 1680 | 0.8 | 104.3 |
| 1740 | 0.0 | 104.6 |
| 1800 | 5.5 | 104.9 |
| 1860 | 0.0 | 105.1 |
| 1920 | 14.5 | 105.3 |
| 1980 | 0.0 | 105.4 |
| 2040 | 27.7 | 105.7 |
| 2100 | 0.0 | 105.8 |
| 2160 | 5.6 | 105.9 |
| 2220 | 9.9 | 106.0 |
| 2280 | 1.3 | 106.1 |
| 2340 | 0.0 | 106.5 |
| 2400 | 8.6 | 106.9 |
| 2460 | 0.0 | 107.1 |
| 2520 | 15.5 | 107.4 |
| 2580 | 0.0 | 107.5 |
| 2640 | 27.4 | 107.9 |
| 2700 | 0.0 | 108.0 |
| 2760 | 0.0 | 108.3 |
| 2820 | 0.0 | 108.4 |
| 2880 | 24.7 | 108.8 |
| 2940 | 0.0 | 108.9 |
| 3000 | 18.2 | 109.1 |
| 3060 | 56.3 | 109.3 |
| 3120 | 40.3 | 109.5 |
| 3180 | 34.5 | 109.7 |
| 3240 | 0.0 | 109.8 |
| 3300 | 34.8 | 109.9 |
| 3360 | 9.9 | 110.3 |
| 3420 | 26.0 | 110.6 |
| 3480 | 25.5 | 110.9 |
| 3540 | 3.2 | 111.2 |
| 3600 | 28.3 | 111.5 |
| 3660 | 25.2 | 111.5 |
| 3720 | 25.6 | 111.6 |
| 3780 | 22.2 | 111.9 |
| 3840 | 0.0 | 112.2 |
| 3900 | 8.7 | 112.5 |
| 3960 | 9.4 | 112.7 |
| 4020 | 14.6 | 112.9 |
| 4080 | 12.2 | 113.0 |
| 4140 | 0.0 | 113.1 |
| 4200 | 0.0 | 113.2 |
| 4260 | 0.0 | 113.2 |
| 4307 | 0.0 | 113.2 |

12.02.02.01 – Wind Tunnel FTTP Procedure

- Please refer to the letter with subject "Request to Use Indoor Facility to Determine Running Loss Fuel Tank Temperature Profiles" from Dave Kulp (Ford Motor Company) to Thomas Ball (EPA) dated November 20, 1996 and Reviewed and Accepted on March 21, 1997.
- Please refer to the letter with subject "Indoor Facility to Determine Running Loss Fuel Tank Temperature Profiles (FTTPs)" from Dave Kulp (Ford Motor Company) to R.B. Summerfield (CARB) dated June 2, 1997.
- Please refer to the letter with subject "Request to Use New Indoor Facility to Determine Fuel Tank Temperature Profiles" from Neil Whitbeck (Ford Motor Company) to E. A. Bontekoe (EPA) dated August 6, 2001 and Reviewed and Accepted on October 30, 2001.
- Please refer to the letter with subject "New Indoor Facility to Determine Running Loss Fuel Tank Temperature Profiles (FTTPs)" from Dave Kulp (Ford Motor Company) to R. B. Summerfield (EPA) dated July 9, 2002.
- Please refer to the letter with subject "Fuel Tank Temperature Profile (FTTP) Correlation Demonstration – Laboratory versus Track" from Dennis Pawlak (Ford Motor Company) to M. Reineman (EPA) dated December 2, 2005 and Reviewed and Accepted on December 2, 2005.

| Program | Vehicle Name | Transmission | Engine | Conv. Dia. | K- Factor | Program Code | CFDR | Torque Converter Designation | Part 1 Code | | | Nominal Torque Ratio | Nominal K | Stall Torque Ratio | | Stall Speed RPM@Torque | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Front Wheel Drive* | | | | | | | | | | | | | | lower | upper | lower | upper |
| B299N | Fiesta | DPS6 | 1.6L TiVCT | NA | NA | CQ | 3.9 | N | CQ | 390 | N | NA | NA | NA | NA | NA | NA |
| C346N | N. American Focus | DPS6 | 2.0L GDI | NA | NA | CW | 3.85 | N | CW | 385 | N | NA | NA | NA | NA | NA | NA |
| C346N | N. American Focus | Magna BEV | N/A | NA | NA | WA | 7.82 | 1 | WA | 782 | 1 | NA | NA | NA | NA | NA | NA |
| V227 | American Transit Conr | 4F27E | 2.0L I4 | 9 1/4" | 250 | D2 | 3.961 | C | D2 | 396 | C | 2.1 | 250 | 1.6 | 2.6 | 2380 | 2790 |
| C520 FWD | Escape | 6F35 | 2.5L I4 | 10.93 | 213 | W6 | 3.51 | A | W6 | 351 | A | 1.95 | 213 | 1.85 | 2.05 | 2499 | 2719 |
| U502/U387 FWD/ D472 FWD | Explorer/Edge/ Limo | 6F35 | 2.0L I4 | 11.03 | 235 | W6 | 3.36 | B | W6 | 336 | B | 2 | 235 | 1.9 | 2.1 | 2768 | 2989 |
| U502 FWD | Explorer | 6F35 | 2.0L I4 | 11.03 | 235 | W6 | 3.51 | B | W6 | 351 | B | 2 | 235 | 1.9 | 2.1 | 2768 | 2989 |
| U387 FWD | Edge | 6F35 | 2.0L I4 | 11.03 | 235 | W6 | 3.21 | B | W6 | 321 | B | 2 | 235 | 1.9 | 2.1 | 2768 | 2989 |
| CD391 FWD | Fusion/Milan | 6F35 | 2.5L I4 | 10.93 | 213 | W6 | 3.07 | A | W6 | 307 | A | 1.95 | 213 | 1.85 | 2.05 | 2499 | 2719 |
| C520 FWD/AWD D258 FWD | Escape Taurus | 6F35 | 2.0L I4 | 11.03 | 235 | W6 | 3.07 | B | W6 | 307 | B | 2 | 235 | 1.9 | 2.1 | 2572 | 2793 |
| C520 FWD | Escape | 6F35 | 1.6L I4 | 10.5 | 231 | W6 | 3.21 | C | W6 | 321 | C | 2.05 | 231 | 1.95 | 2.16 | 2588 | 2860 |
| C520 AWD | Escape | 6F35 | 1.6L I4 | 10.5 | 231 | W6 | 3.51 | C | W6 | 351 | C | 2.05 | 231 | 1.95 | 2.16 | 2588 | 2860 |
| CD391 FWD | Fusion/Milan | 6F35 | 2.0L I4 | 10.96 | 235 | W6 | 3.21 | D | W6 | 321 | D | 1.94 | 235 | 1.84 | 2.03 | 2775 | 3066 |
| CD391 AWD | Fusion/Milan | 6F35 | 2.0L I4 | 10.96 | 235 | W6 | 3.36 | D | W6 | 336 | D | 1.94 | 235 | 1.84 | 2.03 | 2775 | 3066 |
| CD391 FWD | Fusion/Milan | 6F35 | 1.6L I4 | 10.5 | 231 | W6 | 3.07 | C | W6 | 307 | C | 2.05 | 231 | 1.95 | 2.16 | 2588 | 2860 |
| CD391 FWD | Fusion/Milan | 6F35 | 1.6L I4 | 10.5 | 231 | W6 | 3.21 | C | W6 | 321 | C | 2.05 | 231 | 1.95 | 2.16 | 2588 | 2860 |
| U387 FWD | Edge | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.16 | D | WJ | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U387 AWD | Edge | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.16 | D | WJ | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U387 AWD | Edge | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U387 FWD | Edge Sport | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.16 | D | WJ | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U387 AWD | Edge Sport | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U388 FWD | MKX | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.16 | D | WJ | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U388 AWD | MKX | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D472 FWD | MKT | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.16 | D | WJ | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D258 FWD | Taurus | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.16 | D | WJ | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D258 FWD | Taurus | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 2.77 | D | WJ | 277 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D258 FWD | Taurus Police | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.16 | D | WJ | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D258 AWD | Taurus | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D258 AWD | Taurus Police | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D258 AWD | Taurus Police | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D385FWD | MKS | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.16 | D | WJ | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D385AWD | MKS | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U502 FWD | Explorer | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U502 AWD | Explorer | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.65 | D | WJ | 365 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| CD533 FWD | MKZ | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| CD533 AWD | MKZ | 6F50 | 3.7L TiVCT | 9.7 | 160 | WJ | 3.65 | D | WJ | 365 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D471FWD | FLEX | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.39 | D | WJ | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D471AWD | FLEX | 6F50 | 3.5L TiVCT | 9.7 | 160 | WJ | 3.65 | D | WJ | 365 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |

| Program | Vehicle Name | Transmission | Engine | Conv. Dia. | K- Factor | Program Code | CFDR | Torque Converter Designation | Part 1 Code | | | Nominal Torque Ratio | Nominal K | Stall Torque Ratio | | Stall Speed RPM@Torque | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D258 AWD | Taurus SHO | 6F55 | 3.5 V6 (GTDI) | 9.7 | 160 | CG | 2.77 | D | CG | 277 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D258 AWD | Taurus SHO TrackPack | 6F55 | 3.5 V6 (GTDI) | 9.7 | 160 | CG | 3.16 | D | CG | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D385AWD | MKS | 6F55 | 3.5 V6 (GTDI) | 9.7 | 160 | CG | 2.77 | D | CG | 277 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D258 AWD | Taurus Police | 6F55 | 3.5 V6 (GTDI) | 9.7 | 160 | CG | 3.16 | D | CG | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D472 AWD | Livery | 6F55 | 3.7L TiVCT | 9.7 | 160 | CG | 3.16 | D | CG | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U502 AWD | Explorer Sport | 6F55 | 3.5 V6 (GTDI) | 9.7 | 160 | CG | 3.16 | D | CG | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U502 FWD | Explorer Police | 6F55 | 3.7L TiVCT | 9.7 | 160 | CG | 3.39 | D | CG | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U502 FWD | Explorer Trailer Tow | 6F55 | 3.5L TiVCT | 9.7 | 160 | CG | 3.39 | D | CG | 339 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U502 AWD | Explorer Police | 6F55 | 3.7L TiVCT | 9.7 | 160 | CG | 3.65 | D | CG | 365 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| U502 AWD | Explorer Trailer Tow | 6F55 | 3.5L TiVCT | 9.7 | 160 | CG | 3.65 | D | CG | 365 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D472 AWD | Limo | 6F55 | 3.7L TiVCT | 9.7 | 160 | CG | 3.65 | D | CG | 365 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D471AWD | FLEX | 6F55 | 3.5 V6 (GTDI) | 9.7 | 160 | CG | 3.16 | D | CG | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| D472 AWD | MKT | 6F55 | 3.5 V6 (GTDI) | 9.7 | 160 | CG | 3.16 | D | CG | 316 | D | 1.8 | 160 | 1.3 | 2.3 | 1560 | 2360 |
| CD391 FHEV | Fusion Hybrid | HF35 | 2.0L I4 (Atk.) | N/A | N/A | EJ | 3.61 | N/A | EJ | 361 | 1 | N/A | N/A | N/A | N/A | N/A | N/A |
| CD391 PHEV | Fusion Hybrid | HF35 | 2.0L I4 (Atk.) | N/A | N/A | EJ | 4.09 | N/A | EJ | 409 | 1 | N/A | N/A | N/A | N/A | N/A | N/A |
| CD533 FHEV | MKZ Hybrid | HF35 | 2.0L I4 (Atk.) | N/A | N/A | EJ | 3.61 | N/A | EJ | 361 | 1 | N/A | N/A | N/A | N/A | N/A | N/A |
| C344 FHEV | C- Max Hybrid | HF35 | 2.0L I4 (Atk.) | N/A | N/A | EJ | 3.61 | N/A | EJ | 361 | 1 | N/A | N/A | N/A | N/A | N/A | N/A |
| C344 PHEV | C- Max Hybrid | HF35 | 2.0L I4 (Atk.) | N/A | N/A | EJ | 4.09 | N/A | EJ | 409 | 1 | N/A | N/A | N/A | N/A | N/A | N/A |

| Program | Vehicle Name | Transmission | Engine | Conv. Dia. | K- Factor | Program Code | CFDR | Torque Converter Designation | Part 1 Code | | Nominal Torque Ratio | Nominal K | Stall Torque Ratio | | Stall Speed RPM@Torque | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rear Wheel Drive* | | | | | | | | | | | | | | | | |
| VN127 | E-Series (U 8500) | 4R75 | 4.6L 2V | 12" | 145 LO | B7 | | F | B7 | F | 2.334 | 142.3 | 1.8 | 2.8 | 1343 | 2143 |
| VN127 | E-Series (U 8500) | 4R75 | 5.4L 2V | 12" | 110 | B7 | | D | B7 | D | 2.009 | 112.9 | 1.5 | 2.5 | 983 | 1783 |
| HCD339 | Low Cab Forward | 5R110W | 4.5L Diesel | 12" | 110 | BE | | C | BE | C | 2.11 | 110.8 | 1.6 | 2.6 | 1497 | 2151 |
| P473, VN127, F53, F59 | F-SuperDuty, Econoline, Motorhome | 5R110W | 6.8L 2V & 3V | 12" | 95 | TQ | | A | TQ | A | 1.851 | 94.6 | 1.4 | 2.4 | 1698 | 2060 |
| VN127 | Econoline | 5R110W | 5.4L 2V | 12" | 110 | TQ | | C | TQ | C | 2.11 | 110.8 | 1.6 | 2.6 | 1497 | 2151 |
| U222/U354 | Expedition/ | 6R80 | 5.4L | 11" | 126 | C3 | | C | C3 | C | 2 | 126 | 1.9 | 2.1 | 2083 | 2449 |
| P415/U228 | F150/Navigator | 6R80 | 5.4L | 11" | 126 | C3 | | C | C3 | C | 2 | 126 | 1.9 | 2.1 | 2083 | 2449 |
| P415/S197 | F150/Mustang | 6R80 | 3.7 | 10 1/4" | 155 | C3 | | D | C3 | D | 1.78 | 154.9 | 1.68 | 1.88 | 2300 | 2580 |
| P415/S197 | F150/Mustang | 6R80 | 5.0L | 11" | 125 | C3 | | E | C3 | E | 2 | 126 | 1.9 | 2.1 | 2400 | 2700 |
| P415 | F150 | 6R80 | 3.5L | 11" | 142 | C3 | | G | C3 | G | 2 | 142 | 1.9 | 2.1 | 2630 | 2900 |
| P415 | F150/Navigator | 6R80 | 6.2L | 11" | 126 | C3 | | C | C3 | C | 2 | 126 | 1.9 | 2.1 | 2300 | 2620 |
| P473 | Superduty | 6R140 | 6.7L | 12.6" | 90K | CV | | A | CV | A | 1.916 | 93 | 1.98 | 2.19 | 2300 | 2650 |
| P473 | Superduty | 6R140 | 6.2L | 12" | 129K | CP | | B | CP | B | 1.929 | 134 | 1.94 | 2.15 | 2150 | 2500 |
| H561 | Med Dty | 6R140 | 6.8L | 12" | 129K | CP | | B | CP | B | 1.929 | 134 | 1.94 | 2.15 | 2150 | 2500 |

# 2013 4R70W/4R75E AUTOMATIC TRANSMISSION SUMMARY (Index Reference 12.03.01.00)

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transmission Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| B7D | Automatic | 4 | Yes | 2.84:1 | a/ | 12 | 1.5 - 2.5 | 983 – 1783 @150 |
| B7F | " | " | " | 1.55:1 | a/ | 12 | 1.8 – 2.8 | 1343 – 2143 @150 |
| | | | | 1.00:1 | | | | |
| | | | | 0.70:1 | | | | |
| | | | | | | | | |

a/ The transmission shift schedule is contained within the Powertrain Control Module (PCM).

Updated: 08/15/2011

General Description: The 4R70W and 4R75E are electronically controlled; fully automatic 4 speed overdrive transmissions with input through a two phase, single stage torque converter. The torque converter incorporates an internal friction clutch which transmits engine torque mechanically when applied. The shift points and converter clutch application are a function of throttle position and vehicle speed. Each powertrain calibration contains the individual shift points for the corresponding transmission application.

Special Features: The torque converter includes unique hardware which enables the PCM to electronically control clutch apply and release. The powertrain calibration determines the operation of this feature. A Transmission Control Switch (TCS) is located on (or near) the transmission range selector lever and allows the operator to disable and re-enable 4th gear operation. The switch and control logic are designed so that the vehicle always powers up with 4th gear enabled. A Transmission Control Indicator Lamp (TCIL) gives visual indication of "O/D OFF"; and upon flashing, indicates when a Transmission Diagnostic Trouble Code(s) has been stored.

Torque Converter Operation: The application of the converter clutch is scheduled electronically according to the powertrain calibration in 2nd, 3rd, or 4th gear. The apply conditions are contingent upon the following:

- Throttle position is above a closed throttle breakpoint.
- Throttle position is not changing rapidly.
- Brakes are not applied.
- Transmission has warmed up sufficiently.
- Transmission range selector lever is not in reverse or manual low.
- Transmission is not operating in first gear.

## 2013 5R110W AUTOMATIC TRANSMISSION SUMMARY (Index Reference 12.03.01.00)

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transmission Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| BEC (Diesel w/ 110K) | Automatic | 5 | Yes | 3.114:1 | a/ | 12 | 1.61 – 2.61 | 1497 – 2151 rpm @ 200 ft-lb |
| TQA (Gas w/ 95K) | | | | 2.202:1 | | 12 | 1.36 – 2.36 | 1698 – 2060 rpm @ 200 ft-lb |
| TQC (Gas w/ 110K) | | | | 1.545:1 | | 12 | 1.61 – 2.61 | 1497 – 2151 rpm @ 200 ft-lb |
| | | | | 1.00:1 | | | | |
| | | | | 0.707:1 | | | | |

a/ The transmission shift schedule is contained within the Powertrain Control Module (PCM) for gas engine vehicles and the Transmission Control Module (TCM) for diesel engine vehicles.

General Description: The 5R110W is an electronically controlled, fully automatic 5 speed overdrive transmission with input through a two phase, single stage torque converter. The torque converter incorporates an internal friction clutch which transmits engine torque mechanically when applied. The shift points and converter clutch application are a function of throttle position and vehicle speed. Each powertrain calibration contains the individual shift points for the corresponding transmission application.

Special Features: The torque converter includes unique hardware which enables the PCM to electronically control clutch apply and release. The powertrain calibration determines the operation of this feature. The Tow/Haul Mode (THM) Switch is an On/Off switch located on the end of the transmission range selector lever or on the dash, depending on vehicle application. It allows the operator to select a mode that changes the transmission operation for use when driving with a heavy load, trailer towing or when additional engine braking is required. The switch and control logic are designed so that the vehicle always powers up with the THM feature disabled (except on U-Haul Chassis/Cutaway fleet vehicles). A Tow/Haul Mode Indicator Lamp gives visual indication when the THM feature is selected; and upon flashing, indicates when Transmission Diagnostic Trouble Code(s) have been stored.

Torque Converter Operation: The application of the converter clutch is scheduled electronically according to a specific powertrain calibration and may lockup in all five (5) forward gears. The apply conditions are contingent upon the following:

- Throttle position is above a closed throttle breakpoint.
- Throttle position is not changing rapidly.
- Transmission has warmed up sufficiently.
- Transmission range selector lever is not in reverse or manual low.

Revised: 07/22/2011

## 2013 6F35 AUTOMATIC TRANSAXLE SUMMARY (Index Reference 12.03.01.00)

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transaxle Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| W6351A | Automatic | 6 | Yes | 1st 4.584 | a/ | 10.93 | 1.85 - 2.05 | 2499 - 2719 @ 150 |
| W6321A | " | " | " | 2nd 2.964 | a/ | 10.93 | 1.85 - 2.05 | 2499 - 2719 @ 150 |
| W6307A | " | " | " | 3rd 1.912 | a/ | 10.93 | 1.85 - 2.05 | 2499 - 2719 @ 150 |
| W6336B | " | " | " | 4th 1.446 | a/ | 11.03 | 1.9 - 2.1 | 2768 –2989 @ 150 |
| W6321B | " | " | " | 5th 1.000 | a/ | 11.03 | 1.9 - 2.1 | 2768 –2989 @ 150 |
| W6351B | " | " | " | 6th 0.746 | a/ | 11.03 | 1.9 - 2.1 | 2768 –2989 @ 150 |
| W6307B | " | " | " | Rev -2.943 | a/ | 11.03 | 1.9 - 2.1 | 2768 –2989 @ 150 |
| W6321C | " | " | " | | a/ | 10.5 | 1.73 - 1.93 | 2523 – 2793 @ 150 |
| W6351C | " | " | " | | a/ | 10.5 | 1.73 - 1.93 | 2523 – 2793 @ 150 |
| W6321D | " | " | " | | a/ | 11.03 | 1.9 - 2.1 | 2573 –2793 @ 150 |
| W6336D | " | " | " | | a/ | 11.03 | 1.9 - 2.1 | 2573 –2793 @ 150 |

a/ The transaxle shift schedule is contained within the Powertrain Control Module (PCM).

Updated: 8/24/10

General Description: The 6F35 is an electronically controlled, fully automatic 6 speed overdrive transaxle with input through a two phase, single stage torque converter. The torque converter incorporates an internal friction clutch which transmits engine torque mechanically when applied. The shift points and converter clutch application are a function of throttle position and vehicle speed. Each powertrain calibration contains the individual shift points for the corresponding transaxle application.

Special Features: The PCM electronically controls The Torque Converter Clutch apply and release. The powertrain calibration determines the operation of this feature. An O/D cancel feature is standard with grade assist. New TSC (transmission system characterization) process requires VO to flash vehicle PCM with a unique TRID data provided by the transmission assembly plant. A Multi-function Warning Lamp gives visual indication when a Transaxle Diagnostic Trouble Code(s) has been stored. The "wrench" light located in the lower left of IP is for continuous codes set during the present power-up and the MIL light "engine shape" is centered in the IP.

Torque Converter Operation: The application of the converter clutch is scheduled electronically according to the powertrain calibration. The apply conditions are contingent upon the following:

- Throttle position is above a closed throttle breakpoint.
- Throttle position is not changing rapidly.
- Brakes are not applied.
- Transaxle has warmed up sufficiently.

- Transaxle range selector lever is not in reverse or manual low.
- Transaxle is not operating in first, second and third gears.

## 2013 6R80 AUTOMATIC TRANSmission SUMMARY (Index Reference 12.03.01.00)

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Trans Shift Schedule | Torque Converter Characteristics Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
|---|---|---|---|---|---|---|---|---|
| C3A | Automatic | 6 | Yes | 4.171:1 | a/ | 10 ¼ | 1.68/1.88 | 2358/2762 |
| | | | | 2.340:1 | | | | |
| | | | | 1.521:1 | | | | |
| | | | | 1.143:1<br>0.867:1<br>0.691:1 | | | | |
| | | | | | | | | |
| C3C | ' | " | " | | " | 11 | 1.9/2.1 | 2083/2449 |
| C3D | " | " | " | | " | 10 ¼ | | 2300/2580 |
| C3E | " | " | " | | " | 11" | 1.9/2.1 | 2400/2700 |
| C3F | " | " | " | | " | 10 ¼" | 1.68/1.88 | 3070/3315 |
| C3G | " | " | " | | " | 11 | 1.9/2.1 | 2630/2900 |
| | | | | | | | | |

a/ The trans shift schedule is contained within the Transmission Control Module (TCM).

Updated: 08/28/10

General Description: The 6R60/80 is an electronically controlled, fully automatic 6 speed overdrive trans with input through a two phase, single stage torque converter. The torque converter incorporates an internal friction clutch which transmits engine torque mechanically when applied. The shift points and converter clutch application are a function of throttle position and vehicle speed. Each powertrain calibration contains the individual shift points for the corresponding trans application.

Special Features: The torque converter includes unique hardware which enables the TCM to electronically control clutch apply and release. The powertrain calibration determines the operation of this feature. A Transaxle Control Switch (TCS) is located on the transmission range selector lever and allows the operator to disable and re-enable 6th gear operation. The switch and control logic are designed so that the vehicle always powers up with 6th gear enabled. An O/D OFF Lamp gives visual indication when O/D is disabled (ie, cancelled). A Multi-function Warning Lamp gives visual indication when a Transaxle Diagnostic Trouble Code(s) has been stored.

Torque Converter Operation: The application of the converter clutch is scheduled electronically according to the powertrain calibration in 4th, 5th and 6th gears. The apply conditions are contingent upon the following:

- Throttle position is above a closed throttle breakpoint.
- Throttle position is not changing rapidly.
- Brakes are not applied.
- Trans has warmed up sufficiently.
- Trans range selector lever is not in reverse or manual low.
- Trans is not operating in first

# 2013 6R140 AUTOMATIC TRANSMISSION SUMMARY (Index Reference 12.03.01.00)

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transmission Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| (Diesel w/ 90K) | Automatic | 6 | Yes | 1st 3.974<br>2nd 2.318<br>3rd 1.516<br>4th 1.149<br>5th 0.858<br>6th 0.674<br>Rev -3.128 | a/ | 12.6 | 1.82 - 2.01 | 2250 – 2650 rpm @ 770 ft-lb |
| (Gas w/ 129K) | | | | 1st 3.974<br>2nd 2.318<br>3rd 1.516<br>4th 1.149<br>5th 0.858<br>6th 0.674<br>Rev -3.128 | | 12 | 1.88 - 2.08 | 2200 – 2600 rpm @ 350 ft-lb |

a/ The transmission shift schedule is contained within the Powertrain Control Module (PCM) for gas engine vehicles and the Transmission Control Module (TCM) for diesel engine vehicles.

General Description: The 6R140 is an electronically controlled, fully automatic 6 speed overdrive transmission with input through a two phase, single stage torque converter. The torque converter incorporates an internal friction clutch which transmits engine torque mechanically when applied. The shift points and converter clutch application are a function of throttle position and vehicle speed. Each powertrain calibration contains the individual shift points for the corresponding transmission application.

Special Features: The torque converter includes unique hardware which enables the PCM to electronically control clutch apply and release. The powertrain calibration determines the operation of this feature. The Tow/Haul Mode (THM) Switch is an On/Off switch located on the end of the transmission range selector lever or on the dash, depending on vehicle application. It allows the operator to select a mode that changes the transmission operation for use when driving with a heavy load, trailer towing or when additional engine braking is required. The switch and control logic are designed so that the vehicle always powers up with the THM feature disabled. A Tow/Haul Mode Indicator Lamp gives visual indication when the THM feature is selected.

Torque Converter Operation: The application of the converter clutch is scheduled electronically according to a specific powertrain calibration and may lockup in all six (6) forward gears. The apply conditions are contingent upon the following:

- Throttle position.

- Transmission has warmed up sufficiently.
- Transmission range selector lever is not in reverse.

Revised: 08/26/2011

## 2013 B299N 1.6L DPS6 AUTOMATIC POWER SHIFT TRANSMISSION SUMMARY

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transmission Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| CQ390N | Automatic | 6 | Yes (2) | 3.917:1 | a/ | NA | NA | NA |
| | | | | 2.429:1 | | | | |
| | | | | 1.436:1 | | | | |
| | | | | 1.021:1 | | | | |
| | | | | 0.867:1 | | | | |
| | | | | 0.702:1 | | | | |

a/ The transmission shift schedules are contained within the Transmission Control Module (TCM). The TCM is located on the transmission.

General Description: The DPS6 is an power shift transmission, fully automatic manual 6-speed overdrive transmission with input through a cardanic dual clutch. The clutch incorporates a duel internal friction clutch that transmits engine torque mechanically when applied. The basic shift points and clutch application are a function of pedal position and vehicle speed, which may be modified for hilly terrain or trailer tow loads. Each powertrain calibration contains the individual shift points for the corresponding transmission application.

Special Features: The Cardanic clutch includes unique hardware that enables the TCM to electronically control clutch application and release. The powertrain calibration determines the operation of this feature. A mechanical malfunction lamp gives visual indication when a transaxle Diagnostic Trouble Code(s) has been stored.

Cardanic Clutch Operation: The application of the Cardanic clutch is scheduled electronically according to a specific powertrain calibration. The apply conditions are contingent upon the following:

- Vehicle speed.
- Pedal position.
- Transmission has warmed up sufficiently.
- Transmission range selector lever is in drive or low range.

## 2013 C346N 2.0L DPS6 AUTOMATIC POWER SHIFT TRANSMISSION SUMMARY

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transmission Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| CW385N | Automatic | 6 | Yes (2) | 3.917:1 | a/ | NA | NA | NA |
| | | | | 2.429:1 | | | | |
| | | | | 1.436:1 | | | | |
| | | | | 1.021:1 | | | | |
| | | | | 0.867:1 | | | | |
| | | | | 0.702:1 | | | | |

a/ The transmission shift schedules are contained within the Transmission Control Module (TCM). The TCM is located on the transmission.

General Description: The DPS6 is a power shift transmission, fully automatic manual 6-speed overdrive transmission with input through a cardanic dual clutch. The clutch incorporates a duel internal friction clutch that transmits engine torque mechanically when applied. The basic shift points and clutch application are a function of pedal position and vehicle speed, which may be modified for hilly terrain or trailer tow loads. Each powertrain calibration contains the individual shift points for the corresponding transmission application.

Special Features: The Cardanic clutch includes unique hardware that enables the TCM to electronically control clutch application and release. The powertrain calibration determines the operation of this feature. A mechanical malfunction lamp gives visual indication when a transaxle Diagnostic Trouble Code(s) has been stored.

Cardanic Clutch Operation: The application of the Cardanic clutch is scheduled electronically according to a specific powertrain calibration. The apply conditions are contingent upon the following:

- Vehicle speed.
- Pedal position.
- Transmission has warmed up sufficiently.
- Transmission range selector lever is in drive or low range.

## 2013 C346N BEV TRANSMISSION SUMMARY

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transmission Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| WA | Automatic | 1 | N/A | 7.82:1 | a/ | NA | NA | NA |
| | | | | | | | | |

a/ The transmission shift schedules are contained within the Transmission Control Module (TCM). The TCM is located on the gearbox.

General Description: The BEV powertrain is a 1-speed gearbox powered by an electric machine. It is a 2 axis system with an electric machine, an intermediate shaft, and a differential. The differential and electric machine are on the same axis. As a typical automatic transmission system does, the system includes a TRS and a park system. The gearbox lubrication is achieved through splash (there is no pump) using Ford Type A fluid. There is also no cooling circuit for the transmission oil. Cooling for the electric machine is achieved by a water jacket mounted in the housing around where the electric machine stator is press fit (heat shrunk).

Special Features: This system is unique versus a traditional automatic transmission in that in addition to the gearbox, it includes its own powerplant in the electric machine. The electric machine is a 6 pole permanent magnet AC machine. It is controlled by the on board TCM, which includes an inverter module to convert high voltage DC from the battery to three-phase AC voltage for use by the electric machine.

# 2013 HF35 HYBRID AUTOMATIC TRANSMISSION SUMMARY

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transmission Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| EJ4091 | eCVT | Infinite | Yes | N/A | a/ | N/A | N/A | N/A |
| EJ3611 | eCVT | Infinite | Yes | N/A | a/ | N/A | N/A | N/A |

a/ The eCVT does not explicitly command specific gear ratios. It uses torque based control (motor control schedule) which is contained within the Hybrid Powertrain Control Module (HPCM).

b/ The eCVT does not use a torque converter.

General Description: The HF35 is an electronically controlled hybrid Powersplit transaxle containing two high voltage electric machines. The first electric machine (Generator) controls the engine speed and torque levels through a planetary gear set. The second electric machine (Traction Motor) puts torque to the wheels through a fixed gear ratio.

Special Features: The Traction Motor also provides Brake Regeneration Power recovery. New TSC (transmission system characterization) process requires VO to flash vehicle HPCM with a unique TRID data provided by the transmission assembly plant (known as Resolver Offset). Some models also are equipped with an external electric pump for Plug-In Hybrid Electric Vehicle (PHEV) applications. This pump operates only when in pure electric drive mode (engine off) and is speed controlled through the HPCM.

Revised: 09/14/2011

## 2013 6F50/55 AUTOMATIC TRANSAXLE SUMMARY (Index Reference 12.03.01.00)

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transaxle Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| WJ277D | Automatic | 6 | Yes | 1st 4.484 | a/ | 9.7 | 1.3 - 2.3 | 1560 -2360 @ 150 |
| WJ316D | " | " | " | 2nd 2.872 | a/ | 9.7 | 1.3 - 2.3 | 1560 -2360 @ 150 |
| WJ339D | " | " | " | 3rd 1.842 | a/ | 9.7 | 1.3 - 2.3 | 1560 -2360 @ 150 |
| WJ365D | " | " | " | 4th 1.414 | a/ | 9.7 | 1.3 - 2.3 | 1560 -2360 @150 |
| CG277D | " | " | " | 5th 1.000 | a/ | 9.7 | 1.3 - 2.3 | 1560 -2360 @150 |
| CG316D | " | " | " | 6th 0.742 | a/ | 9.7 | 1.3 - 2.3 | 1560 -2360 @150 |
| CG339D | " | " | " | Rev -2.882 | a/ | 9.7 | 1.3 - 2.3 | 1560 -2360 @150 |
| CD365D | " | " | " | | a/ | 9.7 | 1.3 - 2.3 | 1560 -2360 @150 |
| | | | | | | | | |

a/ The transaxle shift schedule is contained within the Powertrain Control Module (PCM).

Updated: 5/16/2012

General Description: The 6F50/55 is an electronically controlled, fully automatic 6 speed overdrive transaxle with input through a two phase, single stage torque converter. The torque converter incorporates an internal friction clutch which transmits engine torque mechanically when applied. The shift points and converter clutch application are a function of throttle position and vehicle speed. Each powertrain calibration contains the individual shift points for the corresponding transaxle application.

Special Features: The PCM electronically controls The Torque Converter Clutch apply and release. The powertrain calibration determines the operation of this feature. Vehicles with SelectShift (SST) permit manual operation of the transmission. For vehicles without SST, a Transaxle Control Switch (TCS) allows the operator to disable and re-enable 6th gear operation. The switch and control logic are designed so that the vehicle always powers up with 6th gear enabled. An O/D OFF Lamp gives visual indication when O/D is disabled (ie, cancelled). A Multi-function Warning Lamp gives visual indication when a Transaxle Diagnostic Trouble Code(s) has been stored. Both lamps are located on the instrument cluster.

Torque Converter Operation: The application of the converter clutch is scheduled electronically according to the powertrain calibration. The apply conditions are contingent upon the following:

- Throttle position is above a closed throttle breakpoint.
- Throttle position is not changing rapidly.
- Brakes are not applied.
- Transaxle has warmed up sufficiently.
- Transaxle range selector lever is not in reverse or manual low.

- Transaxle is not operating in first or second gears.

## 2013MY FN/4F27E AUTOMATIC TRANSAXLE SUMMARY (Index Reference 12.03.01.00)

| A/T Code | Class | No. of Forward Gears | Overdrive | Gear Ratios | Transaxle Shift Schedule | Torque Converter Characteristics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Size (in.) | Stall Torque Ratio | Stall Speed RPM @ Torque (lb.ft.) |
| | | | | 2.82:1 | | | | |
| D2396C | Automatic | 4 | Yes | 1.50:1 | a/ | 9.25 | 1.6 -2.6 | 2380-2790 @ 72 |
| | | | | 1.00:1 | | | | |
| | | | | 0.73:1 | | | | |
| | | | | | | | | |
| | | | | | | | | |

a/ The transaxle shift schedule is contained within the Powertrain Control Module (PCM).

Updated: 1-10-11

General Description: The 4F27E is an electronically controlled, fully automatic 4-speed overdrive transaxle with input through a two phase, single stage torque converter. The torque converter incorporates an internal friction clutch that transmits engine torque mechanically when applied. The shift points and converter clutch application are a function of throttle position and vehicle speed. Each powertrain calibration contains the individual shift points for the corresponding transaxle application.

Special Features: The torque converter includes unique hardware which enables the PCM to electronically control clutch apply and release. The powertrain calibration determines the operation of this feature. A Transaxle Control Switch (TCS) is located on the transmission range selector lever and allows the operator to disable and re-enable 4th gear operation. The switch and control logic are designed so that the vehicle always powers up with 4th gear enabled. An O/D OFF Lamp gives visual indication when O/D is disabled (ie, cancelled). A Multi-function Warning Lamp gives visual indication when a Transaxle Diagnostic Trouble Code(s) has been stored. Both lamps are located on the instrument cluster.

Torque Converter Operation: The application of the converter clutch is scheduled electronically according to the powertrain calibration in 3rd and 4th gears. The apply conditions are contingent upon the following:

- Throttle position is above a closed throttle breakpoint.
- Throttle position is not changing rapidly.
- Brakes are not applied.
- Transaxle has warmed up sufficiently.
- Transaxle range selector lever is not in reverse or manual low.
- Transaxle is not operating in first or second gears.

| 2013 MY MANUAL TRANSMISSION SUMMARY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Part 1 Code** | **Model** | **No. of Forward Gears** | **Overdrive** | **Transaxle Final Drive Ratio** | **Gear Ratios** | **Fluid Type** | **Factory Fill** | **Application(s)** |
| VT323N | MMT6 | 6 | Yes | 4.06 | 3.231 / 1.952 / 1.321 / 1.129 / 1.029 / 0.943<br>4.598 (reverse) | WSD-M2C200-D | 1.75L | Focus ST |
| RP367N | MTX75 | 5 | Yes | 3.82 | 3.67 / 2.136 / 1.448 / 1.028 / 0.805<br>3.727 (reverse) | WSD-M2C200-D | 1.9L | Focus (non-ST) |
| AX424N | MT82 | 6 | Yes | N/A | 4.24 / 2.54 / 1.66 / 1.24 / 1.00 / 0.70<br>3.84 (reverse) | WSD-M2C200-D | 2.6L | 3.7L V6 Mustang S197 |
| AX366N | MT82 | 6 | Yes | N/A | 3.66 / 2.43 / 1.69 / 1.31 / 1.00 / 0.65<br>3.32 (reverse) | WSD-M2C200-D | 2.6L | 5.0L V8 Mustang S197 |
| RN385N | IB5 | 5 | Yes | 4.07 | 3.85 / 2.04 / 1.28 / 0.95 / 0.76<br>3.61 (reverse) | WSD-M2C200-C | 2.1L | Fiesta |
| BT373N | B6 | 6 | Yes | 4.067 | 3.727 / 2.048 / 1.357 / 1.032 / 0.821 / 0.690<br>3.818 (reverse) | WSD-M2C200-D | 1.9L | 1.6L Fusion |
| VE297N | TREMEC TR6060 | 6 | Yes | N/A | 2.97 /1.78 /1.3 /1.0 /0.80 / 0.63<br>2.9 (reverse) | Dextron III Texaco Formulation 1863 | 3.46L | Shelby GT 500 |

* Service fill 90 oz Texaco Formulation 1863 or equivalent (Motorcraft MerconV ATF).

# 2013 MY TRUCK SHIFT SCHEDULES

| SHIFT SURVEY | VEHICLE | DRIVE CYCLE | | | | | Acceleration | | | | | Cruise | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T-NUMBER | DESCRIPTION | C/H | HWY | SC03 | US06 | COMMENTS | 1 - 2 | 2 - 3 | 3 - 4 | 4 - 5 | 5 - 6 | 1 - 2 | 2 - 3 | 3 - 4 | 4 - 5 | 5 - 6 |
| Z | 15, 25, 40, 45 | CM666 | CH665 | CS044 | CU221 | | 15 | 25 | 40 | 45 | | 15 | 25 | 40 | 45 | |
| Z | 15, 25, 40, 45, 50 GENERIC 6-Speed | CM665 | CH664 | CS043 | CU220 | | 15 | 25 | 40 | 45 | 50 | 15 | 25 | 40 | 45 | 50 |
| Z | 15, 25, 40, 45 - GENERIC Hvy. Dty 6-Speed | CM500 | CH501 | N / R | N / R | Omits L-1 Shift Point | 15 | 25 | 40 | 45 | 50 | 15 | 25 | 40 | 45 | 50 |
| | | | | | | | | | | | | | | | | |

# 2013MY CAR SHIFT SCHEDULES

| SHIFT SURVEY | 2013 MY VEHICLE | DRIVE CYCLE | | | | |
|---|---|---|---|---|---|---|
| or Z | SHIFT SCHEDULE DESCRIPTION | C/H | HWY | SC03 | US06 | COMMENTS |
| Z | 15, 25, 40, 45 - GENERIC 5-Speed | CM666 | CH665 | CS044 | CU221 | GENERIC 5-Speed man |
| Z | 15, 25, 40, 45, 50 GENERIC 6-Speed | CM665 | CH664 | CS043 | CU220 | GENERIC 6-Speed man |
| Survey | 1.6L Fiesta w/SIL | CM662 | CH316 | CS013 | CU221 | manual |
| Survey | 2.0L Focus GDI w/SIL | CM662 | CH316 | CS013 | CU221 | manual |
| Survey | 2.0L GTDI Focus ST | CM686 | DH658 | DE646 | CU231 | manual |
| Survey | 1.6L GTDI Fiesta ST | CM686 | DH658 | DE646 | CU231 | manual |
| Z (hwy/uso6 mod) | 1.6L GTDI Escape SST | CM665 | CH677 | CS043 | CU229 | lugging modifications to Z |
| Z | 1.6L GTDI Fusion Manual | CM665 | CH664 | CS043 | CU232 | manual |
| Z | 1.6L GTDI Fusion SST | CM665 | CH664 | CS043 | CU232 | auto |
| Z | 2.0L GTDI Fusion\MKz\Escape SST | CM665 | CH664 | CS043 | CU220 | auto |
| Z | 2.5L Fusion\Escape with SST | CM665 | CH664 | CS043 | CU220 | auto |
| Z | 3.5/3.7L Taurus\MKS\MKZ\Flex\MKt\Edge\MKx | CM665 | CH664 | CS043 | CU220 | auto |
| Z | 3.7 Mustang w/ 2.73 A.R. Manual | CM667 | CH666 | CS045 | CU024 | manual |
| Survey | 3.7 Mustang w/ 3.31 A.R. Manual | CM668 | CH667 | CS046 | CU222 | manual |
| Survey | 5.0L Mustang (skip shift feature gone for 2013) | CM681 | CH676 | DS022 | CU227 | No Skip-Shift for '13 |
| Survey | 5.8L Mustang Shelby GT500 | CM684 | CH675 | DS022 | CU228 | manual |
| | | | | | | |
| Additional schedules and updates revised as available | | | | | | |

## ETHANOL FFV CERTIFICATION VEHICLE "SIMPLIFIED" C-PREP PROCEDURE

SPECIAL PREP CYCLE TO ADAPT A VEHICLE TO A NEW FUEL TYPE (WITH DIFFERENT ETHANOL CONTENT) PRIOR TO THE NEXT TEST PROCEDURE

| START | FINISH | |
|---|---|---|
| | | 1. **KEY MUST BE OFF** > DRAIN FUEL TANK TO EMPTY |
| | | 2. START THE ENGINE AND IDLE FOR **60** SECONDS > **TURN KEY OFF** |
| | | 3. **KEY MUST BE OFF** > ADD **40%** FILL OF THE SPECIFIED TEST FUEL (40% = ________ GAL.) (FUEL CODE ______________________________ ) |
| | | 4. **CONDUCT EPA74 DYNO PREP CYCLE.** |

In addition to the "Simplified" C-Prep steps shown above, the following modification will be made to all FFV emissions test procedures:

- The initial drain and 40% fill will be included for all emissions tests (even in cases where the regulations allow for waiver of the initial drain and fill). This requirement is being added to allow the official FTP to represent a typical start-up condition where alcohol learning has completed following a refueling event.

## ORVR Test Procedure for Ethanol Fuel-Flexible Vehicles (FFV)

Ford Motor Company (Ford) follows the ORVR (On-Board Refueling Vapor Recovery) refueling emissions test procedure, as depicted by Figure B98-12 below, from the federal regulations (sections 86.152-86.154). The ORVR test procedure for fuel flexible vehicles is to fill to 40% with E85 and perform a preconditioning drive, fill to 40% with E85 and perform a Federal Test Procedure (FTP), fill to 10% with E85, and then refuel with E0. Ford has selected E85 and E0 because they are believed to represent the two commonly used commercial fuels for FFVs and therefore represent in-use ORVR refueling practices. It is believed that the E85 and E0 blend that occurs during the refueling portion of the test is the blend expected to result with the highest emission vapors for the ORVR test.

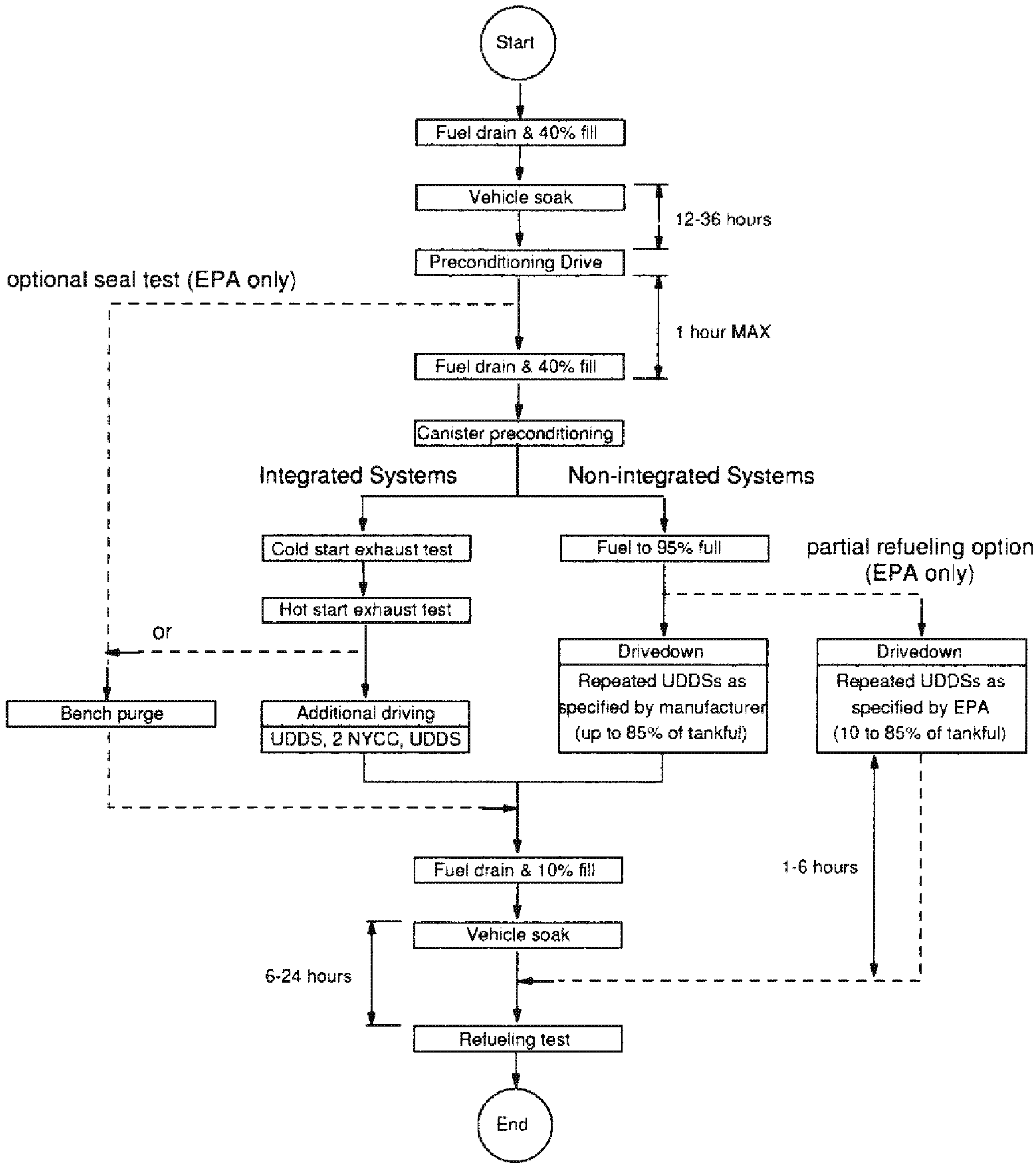



Figure B98-12: Refueling Test Sequence

**Ford Motor Company**
**2013 Model Year Common Section Application**

12.04.02.04 – **Alternate Canister Load**

Please refer to the letter with subject "Alternate Canister Preconditioning" from Dave Kulp (Ford Motor Company) to Eldert Bontekoe (EPA) dated February 22, 2001 and Reviewed and Accepted on February 28, 2001.

12.04.02.05 – **SHED Calibration**

Please refer to the letter with subject "Approval to Use CARB – Specified Evaporative Emission Calibration Procedures" from Dave Kulp (Ford Motor Company) to Marty Reineman (EPA) dated December 19, 2002.

12.04.02.06 – **Road-speed modulated fan for US06 testing**

On July 20, 2012, Ford received blanket approval to use the Road Speed Fan during US06 testing for our GTDI products, ranging from 1.0L to 3.5L. This fan provides air flow that better represents on-road cooling conditions experienced by our GTDI products. For reference, this approval is consistent with LEVIII, which will allow use of a road speed fan all chassis certified vehicles during the US06 test.

**SPECIAL PCM REFLASH PRECONDITIONING PROCEDURES**

The Profile Learning Cycle (PLC) procedure is conducted to ensure mature and stable Keep Alive Memory (KAM) information that allows the emissions control systems to respond as they would under normal operation. Two key components of KAM which are necessary to produce representative emissions and fuel economy results are the crankshaft profile and adaptive fuel corrections. The crankshaft profile must be learned and stored to enable the OBD-II misfire monitor. Until it is learned the vehicle may exhibit more frequent fuel shut-off events on decelerations. The adaptive fuel corrections are necessary for proper air-fuel control.

In many cases, reflash or PCM changes are required after the initial 4K mileage has been conducted. In that instance, and additionally after a loss of power to the PCM (e.g. battery disconnect for maintenance, battery drain, etc.), additional preconditioning to relearn the KAM must be conducted in order for the vehicle to be tested in a representative state.

This preconditioning cycle, known as the Profile Learning Cycle (PLC) consists of the following elements:
- Warm-up (4 min 60 mph steady speed drive or 5 minute idle)
- Three in-gear coastdowns from 60 – 40 mph with no brake actuation
- US06 drive cycle* (no sampling)
- EPA 74 drive cycle (no sampling)

The warm-up drive or idle plus in-gear coastdowns are used to set the misfire monitor. The US06 and EPA 74 drive cycles are conducted to learn the fuel tables at the speed/load points where the vehicle will be tested. Additionally, the EPA 74 can serve as the prep cycle for the subsequent test. This method establishes a procedure to set the misfire monitor in the same manner as would be done during normal customer driving.

The PLC is to be used after any recalibration, PCM replacement, or loss of power to the PCM. This procedure may also be used to condition test vehicles that have not been operated for extended periods of time. This preconditioning will ensure the vehicle is in a representative state for further testing.

** Note: for non-SFTP vehicles, this is replaced with an additional EPA 74 drive cycle with no sampling.*

Beginning with some 2011 MY products and all products for 2013 MY and beyond, new misfire technology eliminates the need for in-gear coastdowns to learn the misfire profile correction. For these vehicles, a new preconditioning cycle was devised. This new preconditioning cycle, known as the Alternate Learning Cycle (ALC) consists of the following elements, all without emissions sampling:
- Two HWFET drive cycles
- One US06 drive cycle*
- One EPA 74 drive cycle

| TestNet "Prep of choice" | <---------- | Sequence and Fan | ----------> |
|---|---|---|---|
| ALC_U8500 | 2 X Hwy<br>Fan speed<br>5,300 CFM | + 1 X US06*<br>Fan speed<br>15,000 CFM | + 1 X EPA74<br>Fan speed<br>5,300 CFM |

** Note: for non-SFTP vehicles, this is replaced with an additional EPA 74 drive cycle with no sampling with a prep named ALC_O8500*

## Additional Mileage Accumulation/Maintenance to Ensure Representativeness of EDVs

**(For EDVs with extended periods of vehicle inactivity)**

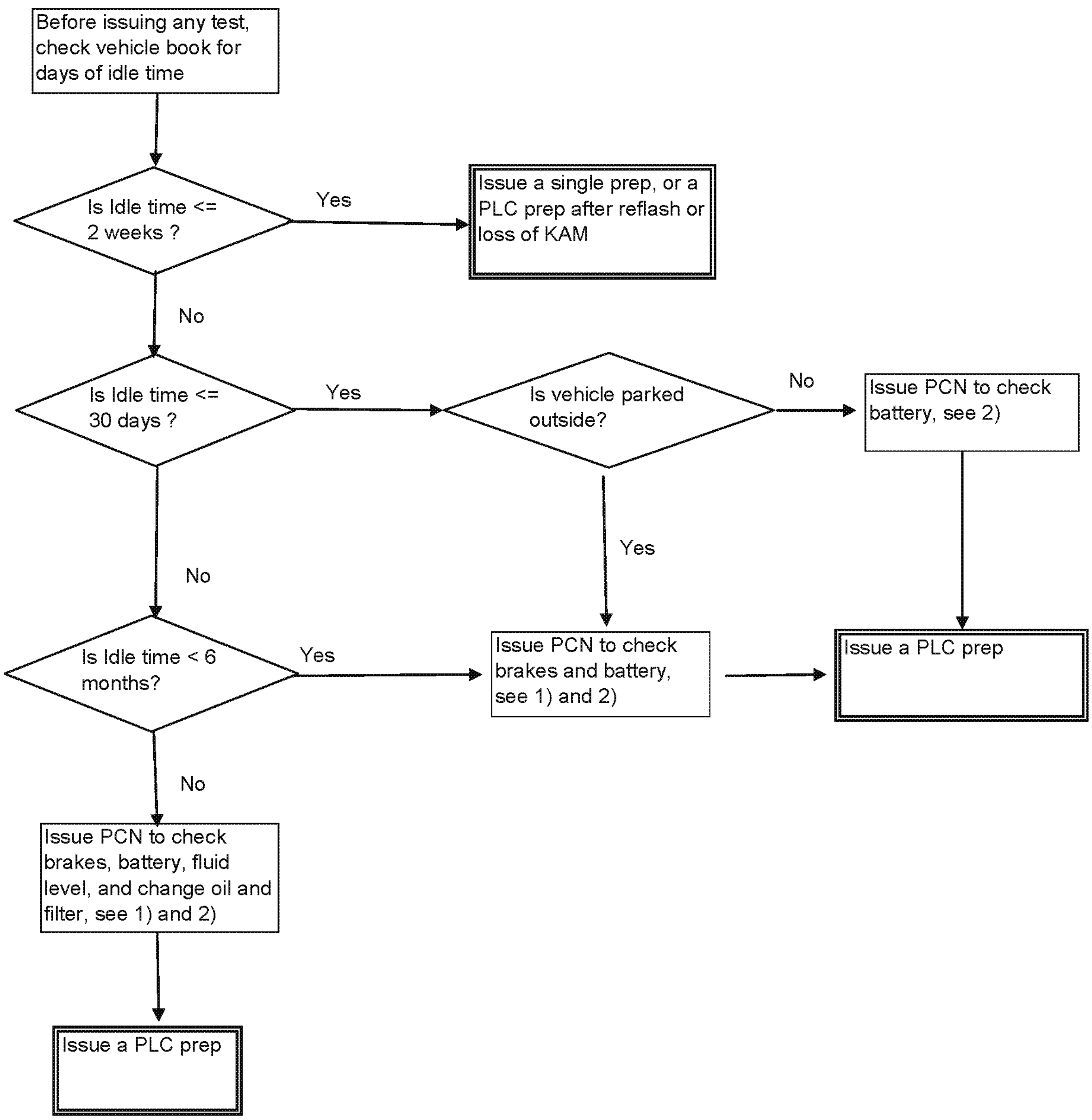
Under normal circumstances, certification vehicles undergoing testing are not expected to be inactive for long periods of time. Such vehicles are representative of real world, in-use conditions, so no additional mileage accumulation, beyond that conducted for initial vehicle break-in, is needed to ensure vehicle emissions stability and in-use representativeness.

However there are occasions when vehicles are not actively tested for extended periods of time (weeks/months), for instance, when waiting for new calibrations or component updates, or when being reconfigured to represent a new model year vehicle. During periods of extended inactivity vehicles are typically parked outside in a parking structure or an impound lot. The inactivity period, coupled with draws on batteries of these vehicles by frequent use of key fobs in the parking lot, may cause battery voltages to drop too low to maintain Keep-Alive Memory (KAM) and PCM functionality. In addition, with uncontrollable weather conditions, brake, tires, and other component functions could be compromised. For the above reasons, it is difficult to ensure these vehicles are in a condition representative of in-use, and/or whether KAM on these vehicles has been maintained. For such vehicles, additional mileage accumulation and/or maintenance may be required to address the unique situations which occur during the certification process, but are not common in-use.

Additional mileage accumulation and maintenance are allowed and justified in the CFR 40 Part 86.1830-01 "Acceptance of vehicle for emissions testing", and CFR 40 Part 86.1831-01 "Mileage accumulation requirement for test vehicle":

- 86.1830-01 (c) (1), "All EVD's shall have at least the minimum number of miles accumulated to achieve stabilized emissions results..."
- 86.1830-01 (c) (2), "...manufacturer may alter any emission data vehicle... in lieu of building a new test vehicle providing that the modification will not impact the representativeness of vehicle's test results. Manufacturer shall use good engineering judgment in making such determinations."
- 86.1830-01 (c) (3), "Components used to reconfigure EDV's under the provisions of paragraph (c)(2) of this section shall be appropriately aged if necessary to achieve representative emission results. Manufacturer shall determine the need for component aging and the type and amount of aging required using good engineering judgment."
- 86.1831-01 (b) (2), "The manufacturer may use an alternative mileage accumulation method providing the form and extent of the service accumulation represents normal driving patterns for that vehicle, the method is consistent with good engineering judgment and the method is described in the application for certification."

Typical additional mileage accumulation and maintenance actions are described in the flow chart (attachment). For vehicles that are parked for weeks, the battery's state of charge is checked using a battery tester e.g. Micro 490 Digital Battery Analyzer, recommended by Ford in its Service Manual used by the dealerships. The battery shall be replaced or charged as needed to ensure adequate/representative state of charge. The brakes are also checked and maintained to ensure safety and representative function. For vehicles inactive longer than 6 months, additional maintenance such as filter and oil change is performed as prescribed via Ford Service Manuals. As documented in the flow-chart, these actions will be followed by the completion of a vehicle drive cycle called Profile Learning Cycle (PLC) to ensure the KAM is relearned and other component functions are stabilized to a condition representative of in-use. The PLC is also described in the Ford's Common Section of the Application 12.04.02.08.




Note:
1) Brakes - repair/ replace as required
2) Battery - Use battery tester such as Micro 490 Digital Battery Analyzer to check battery SOC. Charge as needed

# 2013 MY Application for Emission Certification

**Section 14.01.00.00: Request for Certification/Executive Order and Common Application Statements**

Ford Motor Company (Ford) has elected to submit its 2013 MY Requests for Certificate of Conformity/Executive Order on a test group basis. The "common" material is a part of each individual Request for Executive Order and/or Certificate of Conformity, unless otherwise indicated.

**Section 14.01.01.01: Statement of Compliance**

The test vehicles for which data are submitted to demonstrate compliance with the 2013 MY emissions standards, are in all material respects as described in this Application. These vehicles have been tested in accordance with both good engineering practice and with applicable test procedures, utilizing fuels and equipment in compliance with the regulations. On the basis of such tests, these vehicles have met the requirements described in CAP 2000 Regulation 86.1810-01(b); descriptions of tests performed to ascertain compliance with the said section and the data derived from such tests are available to the EPA Administrator upon request. These vehicles have also met the requirements described in either CAP 2000 Regulation 86.1810-01(c), (86.1811-01 (f))~~,~~ (86.1812-01(f), .86.1813-01(f), .86.1814-01(f), and 86.1815-01(f)) as applicable~~.~~

Pursuant to CAP 2000 regulation 1829-01(b)(1)(ii)(B), and CAP 2000 regulation 1829-01(b)(2)(ii)(B)~~,~~ Ford has conducted testing and engineering evaluations of vehicles representative of 2013 model year light duty vehicle (LDV) and light duty truck (LDT) test groups and evaporative/refueling families. Based on such testing and evaluations, Ford believes that the vehicles in these LDV and LDT test groups have been designed to comply with the applicable exhaust emission standards and evaporative/refueling standards at high altitude.

Further, with respect to CAP 2000 Regulation 86.1810-01(a), Ford states that new motor vehicles of this engine family conform to the terms of the Statement of Device Safety contained in this Application.

The evaporative emission deterioration factors for this evaporative emission family/evaporative emission control system combination have been derived from test data obtained from testing conducted in accordance with good engineering practice to meet the requirements of CAP 2000 regulation 86.1824-01.

**Section 14.01.01.02: Statement of Device Safety**

Ford Motor Company (Ford) states that the emission control devices, systems or elements of design installed on or incorporated in Ford Motor Company new motor vehicles or new motor vehicle engines for the purposes of complying with standards prescribed under Section 202 of the Clean Air Act, will not in their operation, to the best of Ford's information and belief, cause the emission into the ambient air of pollutants which cause or contribute to an unreasonable risk to public health, except as specifically permitted by the standards prescribed under the Clean Air Act.

Ford Motor Company also states that to the best of its information and belief the aforementioned emission control devices, systems or design elements do not in their operation or function, result in any reasonably foreseeable unsafe condition which would unreasonably endanger the motor vehicle, its occupants, or persons or property in close proximity to the vehicle, except that any reasonably foreseeable "unsafe condition" that may occur would result only from conditions of abuse or misuse (including tampering or lack of proper maintenance), or a malfunction that is related to abuse or misuse and which would sufficiently affect vehicle drivability, or otherwise put the driver on notice of the condition, so that a reasonably prudent person would likely to have service performed. In support of the above statement, Ford (or it's suppliers) has designed and carried out a testing and analysis program, in accordance with good engineering practice, designed (1) to identify vehicle operations or functions with respect to which it is reasonable to foresee that an "unsafe condition" would result, (2) to identify the reasonably foreseeable causes of such "unsafe conditions", and (3) to determine if such causes are reasonably likely to affect vehicle drivability, or otherwise put the driver on notice of the "unsafe condition" so that a reasonably prudent person would be likely to have service performed.

Descriptions and results of these tests are available for submission to EPA upon its request.

Statement of Conformity Qualification Information – Gasoline Fueled

General Description of Principal Unsafe Condition(s) Being Qualified

The principal unsafe condition being qualified is catalyst or exhaust system overheating. Typically, the overheating could cause combustible material in contact with the exhaust system to be ignited (e.g., grass fire) or materials inside the vehicle to be damaged (e.g., carpet smoldering or melting).

General Description of the Immediate Cause of the Unsafe Condition Being Qualified

The immediate cause of exhaust system overheating is an excess amount of unburned fuel delivered to the exhaust system in the presence of sufficient air to promote oxidation of the fuel.

Principal Types of Abuse, Misuse, Tampering, or Malfunction, Which Might Cause the Unsafe Condition

The principal types of abuse or misuse or malfunction that might cause catalyst or exhaust system overheating are as follows:

*Abuse/Misuse/Tampering*

Continued driving with an engine over-temperature warning.
Prolonged operation of a vehicle when an overt indication of malfunction exists, e.g., continual operation with an engine that repeatedly misfires.
Excess starter cranking (in excess of 30 seconds) with an intermittently firing or flooded engine.
Disregard of recommended maintenance for the ignition system, fuel system, and emission control system.
Extended high engine speed idle (above normal engine control speed) for more than 5 minutes using a commercial throttle kicker for use as a stationary power source or manually elevating the idle speed above the normal idle speed through the throttle.
Operation of passenger cars in excess of specified maximum passenger and luggage loads and/or maximum recommended trailer weight.
Operation of the light truck in excess of specified GVW and/or GCW.
Tampering or unauthorized modifications to the engine or vehicle such as:
Adjusting ignition timing beyond specified limits.
Altering emissions system components or location or removing components.

*Malfunction*

Ignition system problems, e.g., persistently misfiring spark plugs, ignition module or coil failure, ignition timing retard.

General Identification of the Manner in Which the Principal Causes Would Affect Drivability or Otherwise Put the Driver on Notice

The principal causes generally would result in a significant degradation of vehicle performance with one or more of the following symptoms:

Extended dieseling (more than 5 seconds or engine run-on with key off)
Persistent misfiring
Odor or smoke
Oil pressure, over-temperature, or charge indicator warning
Repetitive stalls or backfires
Heavy surging
Fluid leakage

**Section 14.01.01.03: Statement of Compliance for Unregulated Pollutants**

Statement of Conformance with 40 CFR 86.1810-01(a) and CAA Section 202(a) (4)

Ford Motor Company states that the emission control devices, systems, or elements of design installed or incorporated in Ford's new motor vehicles or new motor vehicle engines are expected to conform to the requirements of 86.1810-01(a) and Section 202(a)(4) of the Clean Air Act, to the best of Ford's knowledge and belief. Information and data pertaining to any tests performed in connection with this statement, including but not limited to the emissions characterization information submitted periodically by Ford to EPA, are available to the Administrator upon request.

**Section 14.01.01.04: Production Engine Parameters**

This Application for Certification identifies and describes those motor vehicle engines to be covered by executive order (s) issued by the California Air Resources Board and/or Certificate(s) of Conformity issued by EPA. This Application for Certification covers only those new motor vehicle engines produced by Ford Motor Company, which conform, in all material respects, to the design specifications, which are contained herein.

The alternate emission control components shown on the parts lists (Sections 16, 3 and 12) are identical with respect to their specifications as shown in the Application for Certification.

**Section 14.01.01.05: Statement of Particulate Emissions**

Pursuant to 86.1829.01(b) (iii) (B), Ford Motor Company asserts that the designs of Ford's Otto-cycle gasoline and methanol fueled vehicles described in the applications are substantially similar to existing designs which have particulate levels significantly below the applicable standards prescribed under CAP 2000 Regulation 86.1811 and 86.1812, .1813, .1814, .1815. Ford also asserts that to the best of its information and belief, these vehicles are expected to demonstrate particulate emission characteristics similar to the existing designs.

**Section 14.01.01.06: Statement of Compliance for Warranty**

The warranty statements contained in Ford Motor Company Warranty Guides comply with all applicable EPA and CARB regulations.

**Section 14.01.01.07: Statement of Low Leak Exhaust**

Ford Motor Company has conducted its analysis and can therefore state that for Tier 2 and interim non-Tier 2 vehicles beginning with the 2009 model year, the exhaust has been designed to facilitate leak-free (CFR 86.1844) assembly, installation, and operation for the full useful life of the vehicle. Additionally, exhaust systems have been designed to facilitate that such repairs as might be necessary on a properly maintained, undamaged, or unaltered used vehicle can be performed in such a manner as to maintain leak-free operation, using tools commonly available in a motor vehicle dealership or independent repair shop for the full useful life of the vehicle.

**Section 14.01.01.08: Statement of Compliance in Lieu of measuring formaldehyde (HCHO) emissions**

As a result of amended 86.1829-01 (b) (1) (iii) (E), manufacturer for gasoline fueled and diesel fueled Tier 2 and Interim non-Tier 2 vehicles may provide a statement in its application for certification that such vehicles comply with the applicable standards in lieu of testing formaldehyde emissions. CARB adopted the EPA regulation unchanged, except vehicles referenced mean California LEVs, ULEVs and SULEVs. (California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-duty Trucks and Medium-duty Vehicles. Part 1, G-3.1.2.). Based on past testing and engineering judgment, where required all vehicles are expected to conform to the applicable HCHO emission standard.

**Section 14.01.01.09: Use of 1.04 NMOG/NMHC Ratio in Lieu of NMOG Testing**

In accordance with 86.1810-01(p) and California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-duty Trucks and Medium-duty Vehicles. Part 1, D-1, Ford has measured NMHC in lieu of NMOG and applied the required adjustment factor.

**Section 14.01.01.10: Certification Short Test (CST)**

Based on engineering evaluation of past CST testing, where required all vehicles are expected to conform with the applicable emission standards under 40 CFR 86.1811-01(f) for which emissions data are not provided, as allowed under 40 CFR 86.1829.01(b)(4)(B).

**Section 14.01.01.11: High Altitude Testing**

Pursuant to 40 CFR 86.1829-01(b)(ii)(B), based on engineering evaluation of appropriate high-altitude emission testing, all light-duty vehicles, light-duty trucks and complete heavy-duty vehicles are expected to comply with the applicable emission standards at high altitude.

**Section 14.01.01.12: 91 RON (Knock Sensor)**

Pursuant to VPCD-97-01, based on testing and engineering judgment, the city and highway fuel economy test result differences between 91 RON operation and 96 RON operation for vehicles equipped with a knock sensor are expected to be within 3%, and there are no emission increases expected (beyond normal test variability) using 91 RON fuel when tested on the FTP cycle (or SFTP cycle as applicable).

**Section 14.01.01.13: Defeat Device Avoidance**

The applicable test groups have been designed and engineered to comply with 40 CFR 86.1809-12, prohibition of defeat devices.

Based on engineering evaluation of intermediate cold temperature emissions test data, the applicable test groups are expected to comply with intermediate cold testing defeat device avoidance requirements as described in 40 CFR 86.1809-12(e).

**Section 14.01.01.14: Fuel Spitback Emissions for ORVR Certified Vehicles**

In accordance with 40 CFR 86.1810-01 (l)(1), manufacturers may provide a statement of compliance in lieu of testing Fuel Spitback emissions for ORVR certified vehicles. Ford Motor Company certifies, to the best of its knowledge and belief, that its ORVR-certified vehicles are designed to meet the fuel dispensing spitback standard as part of compliance with the refueling emission standard. This statement is based on previous emission tests, development tests, other applicable information, and good engineering judgment.

**Section 14.01.01.15: California On Board Diagnostic (OBD) Statement of Compliance**

Ford Motor Company's 2013 MY products are in compliance with the California OBD II regulations (Title 13 CCR sections 1968.2 or 1971.1, as applicable) for the full useful life of the vehicle (e.g., 120,000 for passenger cars and trucks, 150,000 for PZEV / AT-PZEV vehicles).

**Section 14.01.01.16: Air to Fuel Ratio Requirement**

Consistent with 40 CFR 86.1810-01(i)(6) and Part I, Section D, paragraph 2.1.4 of the California Exhaust Emission Standards for 2001 and later light-duty vehicles, the air to fuel ratio is not scheduled to be delivered any richer than the leanest air to fuel mixture required to obtain maximum torque (lean best torque), with the exception of cold-start conditions, warm-up conditions, rapid-throttle motion considerations, ("tip-in" or "tip-out" conditions), and conditions in which additional enrichment is need to protect the engine, emission control hardware, or vehicle and occupants. These conditions are described in section 16.05.00 of the Common Section with key calibratable parameters listed in section 16.00.05.00 of the Certification Application.

**Section 14.01.02.00: Unique CARB requirements**

**Section 14.01.02.01: California Fuel Fill Pipe Compliance**

Ford Motor Company attests that all 2013 Model Year vehicles meet the California fuel fill pipe and corresponding fill pipe access zone requirements.

**Section 14.01.02.02: Label Durability/Environmental Performance Label Statement**

The label material and adhesives of Ford Motor Company Vehicle Emission Control Information (VECI) labels have been designed to withstand typical environmental conditions in the area where the label is attached for the vehicle's total expected life. The Environmental Performance label will utilize the identical materials, color, size, font, style, overall specifications and printing process as approved by ARB on December 4, 2008.

**Section 14.01.02.03: California I/M Tests**

Based on past testing and engineering judgment, where required all vehicles are expected to conform with the applicable emission standards for which emissions data are not provided, as allowed under " California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model PC, LDT and MDV" Part I, G.3.1.4.

In accordance with regulation 40 CFR 86.1818-12, Ford Motor Company states that the following concerning 2013 MY $N_2O$ compliance: Based on engineering evaluation of appropriate $N_2O$ emissions testing, Ford Motor Company attests, to the best of its knowledge and belief, that $N_2O$ tailpipe emissions do not exceed values summarized below:

| Engine size and technology | FTP $N_2O$ FUL tailpipe |
|---|---|
| 3.5L GTDI | 25 mg/mi |
| All other powertrains | 10 mg/mi |

**Valid Test Results (Highest result of a 3 or 4 test sequence):**

| Vehicle | Vehicle ID | Significant Characteristics | $N_2O$ for FTP Std=10 mg/mi |
|---|---|---|---|
| 3.5L GTDI F150 MCR | 312W115 | **GTDI**, High-Vol, Pwr/wt | **20 mg/mi ( @ 120K mi)** |
| 3.5L GTDI Flex | 061W552 | **GTDI** | **26 mg/mi ( @ 90K mi)** |
| 3.5L GTDI MKS | 061W519 | **GTDI** | **21 mg/mi ( @ 120K mi)** |
| | | | |
| 2.0L GTDI U502 - dev | U502 - dev calib | **GTDI** | **< 1 mg/mi (E15, 150K)** |
| | | | |
| 6.2L F350 FFV on E10 | 061W604 | **PFI**, Pwr/wt | **9 mg/mi ( E10, 150K )** |
| 6.2L F350 FFV on E85 | 061W604 | **PFI**, Pwr/wt, FFV | **6 mg/mi ( E85, 150K )** |
| | | | |
| 3.0L Fusion FFV on E0 | 312W205 | **PFI**, High-Vol | **9 mg/mi ( E0, 120K )** |
| 3.0L Fusion FFV on E85 | 312W205 | **PFI**, High-Vol, FFV | **5 mg/mi ( E85, 120K )** |
| | | | |
| 3.5L '13 MY U502 | DGA00013 | **PFI**, High-Vol | **<1 mg/mi (E0, 6K )** |
| | | | |
| 5.0L F150 | 565W921 | **PFI**, High-Vol, Pwr/wt | **1.5 mg/mi (E0, 120K )** |
| | | | |
| 2.0L Focus GDI | 590W134 | **GDI**, High-Vol | **4 mg/mi ( E0, 120K )** |
| | | | |
| HEV '13 MY Fusion | DC71-2.0-E-383 | **HEV** | **<1 mg/mi (E0, 6K )** |
| | | | |

## ADJUSTABLE PARAMETERS

Ford gas engines do not incorporate any parameters that are considered adjustable. Electronic throttle bodies which electrically control the idle airflow setpoint incorporate a throttle stop or mechanical plunger to set the closed position of the throttle plate. This stop is protected by one of the following methods:

1. A threaded plunger provides a stop which is fixed with a thread adhesive and is designed to break-off to prevent adjustment, or
2. An internal drive hex screw provides a stop and is fixed with thread adhesive and designed to strip to prevent adjustment, or
3. An internal gear provides the stop which is laser-welded and does not have any adjustment capability.

**SCR with reagent** -- Ford's diesel engine programs employing SCR systems utilizing a NOx reducing reagent have been reviewed with both EPA and CARB for acceptability with respect to the "adjustable parameter" requirements defined in 40 CFR 86.094-22 and 86.1833.01 and outlined under the guidance provided in the Dear Manufacturer Letters CISD-07-07 and CISD-09-04.

# Heavy Duty Vehicle Speed Simulation Procedure

- Please refer to the letter from Todd M. Fagerman (Ford Motor Company) to K. Jennings (EPA) dated May 27, 2004.
- Please refer to the letter from David L. Kulp (Ford Motor Company) to R.B. Summerfield (ARB) dated October 5, 2001.
- Please refer to the letter from David L. Kulp to John Guy (EPA) dated May 18, 2001.
- Please refer to the letter from R.B. Summerfield to David L. Kulp dated July 29, 1996.
- Please refer to the letter from Chester France (EPA) to David L. Kulp dated July 18, 1996.

# Fuel Recommendation to Vehicle Owners

For 2013 MY Light Duty Vehicle (LDV), Light Duty Truck (LDT), and Heavy Duty Gasoline Engine (HDGE) fuel recommendations, refer to the 2013 MY Owner's Manuals and Service Guides.

# CRANKCASE EMISSION CONTROL SYSTEM DESCRIPTION

## GENERAL CRANKCASE VENTILATION (PCV) SYSTEM

The Ford Crankcase Emission control System is a Closed Loop (CL) ventilation system that is designed to evacuate crankcase gases from the crankcase and prevent them from escaping into the atmosphere. The crankcase control system controls these gases or vapors, otherwise known as "blow-by" gases, by directing them back into the intake manifold where they are consumed in the normal combustion process.

## POSITIVE CRANKCASE VENTILATION (PCV) SYSTEM

The crankcase ventilating air source is the Air Cleaner or Zip Tube. The fresh air passes through a filter located in the air cleaner and then through a hose connecting the air cleaner to the cam/rocker cover(s). The fresh air flows into the overhead and travels throughout the crankcase. The fresh air and blow-by gas leave the crankcase through a flow regulator called a Positive Crankcase Ventilation Valve (PCV valve), and pass into the intake manifold through a connecting hose. The ventilation process goes on continuously while the engine is running.

## Service Manuals and Bulletins

Ford has provided EPA and CARB with the Motorcraft website (www.motorcraftservice.com) and password by which these agencies may access owner guides, warranty guides, shop manuals and technical service bulletins.

## §17 California ARB Information

### 17.01.00.00 – California Fill Pipe Specifications

Refer to Section: 14.01.02.00

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford Fiesta

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle a in degrees. | $-10^{o} \leq \alpha \leq 20^{o}$ | 1° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 31.2° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 7.1 cm |
| (4) Angle ß in degrees. | none | -2.1° |
| (5) Length 'X' in centimeters | none | 0.52 cm |

Fill Pipe Specification

| | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.02 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.25 cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{o}$(min) | 125° |
| (a) degrees extending each side of reference plane. | $35^{o}$ (min) **LS | 62.5° |
| | each side **RS | 62.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.29 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | 1.26 cm |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.48 cm |

Offset

| | | |
|---|---|---|
| Offset A | none | 0.17 cm |
| Offset B | none | 0.08 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford C-Max (Full and Plug-In Hybrid)

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 10.4° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 50.6° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 4.2 cm |
| (4) Angle ß in degrees. | none | 14.6° |
| (5) Length 'X' in centimeters | none | 1.16 cm |

Fill Pipe Specification

| | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.02 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 4.9 cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{\circ}$(min) | 115° |
| (a) degrees extending each side of reference plane. | $35^{\circ}$ (min) **LS | 67.5° |
| | each side **RS | 67.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.35 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | NA |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 1.16 cm |

Offset

| | | |
|---|---|---|
| Offset A | none | 0.068 cm |
| Offset B | none | 0.58 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/15/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford Focus (including ST)

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 1° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 43° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 7.1 cm |
| (4) Angle ß in degrees. | none | -2.1° |
| (5) Length 'X' in centimeters | none | 0.52 cm |

Fill Pipe Specification

| | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.02 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.25 cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{\circ}$(min) | 125° |
| (a) degrees extending each side of reference plane. | $35^{\circ}$ (min) **LS | 62.5° |
| | each side **RS | 62.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.29 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | 1.26 cm |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.48 cm |

Offset

| | | |
|---|---|---|
| Offset A | none | 0.17 cm |
| Offset B | none | 0.08 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group / Evaporative Family All which contain model shown below

Vehicle Model(s) FORD ESCAPE

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 10.4° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 41.3° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 4.2cm |
| (4) Angle ß in degrees. | none | 14.6° |
| (5) Length 'X' in centimeters | none | 1.16cm |

Fill Pipe Specification

| Fill Pipe Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | .02 |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 4.9cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{\circ}$(min) | 115° |
| (a) degrees extending each side of reference plane. | $35^{\circ}$ (min) **LS | 67.5° |
| | each side **RS | 67.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.35cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | N/A |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 1.16cm |

Offset

| Offset | ARB Specification | Manufacturer Specification* |
|---|---|---|
| Offset A | none | 0.068cm |
| Offset B | none | 0.58cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in FAO procedure ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/25/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group / Evaporative Family All which contain the models shown below

Vehicle Model(s) Ford Fusion, Lincoln MKZ (including full and plug-in hybrid

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 10.4° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 34.5° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 4.2cm |
| (4) Angle ß in degrees. | none | 14.6° |
| (5) Length 'X' in centimeters | none | 1.16cm |

Fill Pipe Specification

| | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | .02 |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 4.9cm |
| (3) Internal locking lip in degrees of the inside circumference | 100°(min) | 115° |
| (a) degrees extending each side of reference plane. | 35° (min) **LS each side **RS | 67.5° / 67.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.35cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | N/A |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 1.16cm |

Offset

| | | |
|---|---|---|
| Offset A | none | 0.068cm |
| Offset B | none | 0.58cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in FAO procedure ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 11/19/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford Taurus, Ford Flex, Ford Explorer, Lincoln MKS and Lincoln MKT

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^\circ \leq \alpha \leq 20^\circ$ | 1° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 41.1° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 7.1CM |
| (4) Angle ß in degrees. | none | -2.1° |
| (5) Length 'X' in centimeters | none | 0.52CM |

| Fill Pipe Specification | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.02 CM |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.25CM |
| (3) Internal locking lip in degrees of the inside circumference | $100^\circ$(min) | 125° |
| (a) degrees extending each side of reference plane. | $35^\circ$ (min) **LS | 62.5° |
| | each side **RS | 62.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.29CM |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | 1.26CM |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.48CM |

| Offset | | |
|---|---|---|
| Offset A | none | 0.17CM |
| Offset B | none | 0.08CM |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Engine Family All which contain models listed below

Vehicle Model(s) F53 Motorhome (Stripped Chassis) / F59 Step-Van (Stripped Chassis)

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | -3° to -1.0° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30° (min) | 51.8° (min) |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 5.8 CM |
| (4) Angle $\beta$ in degrees. | none | 4.0° to 4.5° |
| (5) Length 'X' in centimeters | none | 0.77 to 0.83 CM |

Fill Pipe Specification

| | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.025 CM |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.26 CM (max) |
| (3) Internal locking lip in degrees of the inside circumference | 100°(min) | 360° |
| (a) degrees extending each side of reference plane. | 35° (min) **LS each side **RS | 180° (min) 180° (min) |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.35 CM (min) |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | N/A |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.7 to 0.9 CM |

Offset

| | | |
|---|---|---|
| Offset A | none | 0.26 (min) |
| Offset B | none | 0.16 (min) |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in FAO procedure ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 11/03/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013 MY

Manufacturer Ford Motor Company

Test Group / Evaporative Family DFMXF0265NAV

Vehicle Model(s) F650

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 3 |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 30°-35° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 4.831 |
| (4) Angle ß in degrees. | none | 1° |
| (5) Length 'X' in centimeters | none | 1.242 |

Fill Pipe Specification

| | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.025 |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.66-5.74 |
| (3) Internal locking lip in degrees of the inside circumference | $100^{\circ}$(min) | 180° |
| (a) degrees extending each side of reference plane. | $35^{\circ}$ (min) **LS | 60° |
| | each side **RS | 60° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.439 |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | 0.973 |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 1.24 |

Offset

| | | |
|---|---|---|
| Offset A | none | 1.15mm |
| Offset B | none | 0.71mm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in FAO procedure ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 12/07/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford F-150 (excluding SVT Raptor)

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 1° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 46.6° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 7.1 cm |
| (4) Angle ß in degrees. | none | -2.1° |
| (5) Length 'X' in centimeters | none | 0.52 cm |

| Fill Pipe Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.02 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.25 cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{\circ}$(min) | 125° |
| (a) degrees extending each side of reference plane. | $35^{\circ}$ (min) **LS each side **RS | 62.5° / 62.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.29 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | 1.26 cm |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.48 cm |

| Offset | ARB Specification | Manufacturer Specification* |
|---|---|---|
| Offset A | none | 0.17 cm |
| Offset B | none | 0.08 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford F-150 SVT Raptor

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 1° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 52.9° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 7.1 cm |
| (4) Angle ß in degrees. | none | -2.1° |
| (5) Length 'X' in centimeters | none | 0.52 cm |

| Fill Pipe Specification | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.02 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.25 cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{\circ}$(min) | 125° |
| (a) degrees extending each side of reference plane. | $35^{\circ}$ (min) **LS | 62.5° |
| | each side **RS | 62.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.29 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | 1.26 cm |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.48 cm |

| Offset | | |
|---|---|---|
| Offset A | none | 0.17 cm |
| Offset B | none | 0.08 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford F250/F350/F450/F550

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 2.17° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 32.8° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 4.91 cm |
| (4) Angle ß in degrees. | none | 2.93° |
| (5) Length 'X' in centimeters | none | 0.15 cm |

| Fill Pipe Specification | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.025 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 4.86 cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{\circ}$(min) | 162.7° |
| (a) degrees extending each side of reference plane. | $35^{\circ}$ (min) **LS each side **RS | 104.5° / 58.3° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.31 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | NA |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.60 cm |

| Offset | | |
|---|---|---|
| Offset A | none | 0.53 cm |
| Offset B | none | 0.33 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford Mustang

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{o} \leq \alpha \leq 20^{o}$ | 1° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 35.9° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 7.1 cm |
| (4) Angle ß in degrees. | none | -2.1° |
| (5) Length 'X' in centimeters | none | 0.52 cm |

| Fill Pipe Specification | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.02 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.25 cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{o}$(min) | 125° |
| (a) degrees extending each side of reference plane. | $35^{o}$ (min) **LS | 62.5° |
| | each side **RS | 62.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.29 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | 1.26 cm |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.48 cm |

| Offset | | |
|---|---|---|
| Offset A | none | 0.17 cm |
| Offset B | none | 0.08 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Expedition, Expedition EL, Navigator, Navigator L

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 1° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 42.8° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 7.1 cm |
| (4) Angle ß in degrees. | none | -2.1° |
| (5) Length 'X' in centimeters | none | 0.52 cm |

| Fill Pipe Specification | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.02 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.25 cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{\circ}$(min) | 125° |
| (a) degrees extending each side of reference plane. | $35^{\circ}$ (min) **LS | 62.5° |
| | each side **RS | 62.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.29 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | 1.26 cm |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.48 cm |

| Offset | | |
|---|---|---|
| Offset A | none | 0.17 cm |
| Offset B | none | 0.08 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford Edge, Lincoln MKX

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 1° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 32.5° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 7.1 cm |
| (4) Angle ß in degrees. | none | -2.1° |
| (5) Length 'X' in centimeters | none | 0.52 cm |

Fill Pipe Specification

| | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.02 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.25 cm |
| (3) Internal locking lip in degrees of the inside circumference | 100°(min) | 125° |
| (a) degrees extending each side of reference plane. | 35° (min) **LS | 62.5° |
| | each side **RS | 62.5° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.29 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | 1.26 cm |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.48 cm |

Offset

| | | |
|---|---|---|
| Offset A | none | 0.17 cm |
| Offset B | none | 0.08 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Test Group All which contain models shown below

Vehicle Model(s) Ford Transit Connect

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | -2.6° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30 (min) | 40.78° |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 5.048 cm |
| (4) Angle ß in degrees. | none | 1.75° |
| (5) Length 'X' in centimeters | none | 1.27 cm |

Fill Pipe Specification

| | | |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.025 cm |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.66 cm |
| (3) Internal locking lip in degrees of the inside circumference | $100^{\circ}$(min) | 105.2° |
| (a) degrees extending each side of reference plane. | $35^{\circ}$ (min) **LS each side **RS | 52.6° 52.6° |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.318 cm |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | DOES NOT APPLY |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 1.0 cm |

Offset

| | | |
|---|---|---|
| Offset A | none | 0.809 cm |
| Offset B | none | 0.306 cm |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in VEE Guideline ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 10/12/2011

# CALIFORNIA FILL PIPE AND OPENING SPECIFICATIONS

Model Year 2013

Manufacturer Ford Motor Company

Engine Family All which contain models listed below

Vehicle Model(s) E-150/250/350 Vans & Club Wagons, E-350 Econoline Cutaway, E-350 Econoline Stripped Chassis, E-Super Duty Cutaway

The nomenclature and symbols used below are the same as those defined in "Specifications for Fill Pipes and Opening of Motor Vehicle Fuel Tanks."

| General Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Angle $\alpha$ in degrees. | $-10^{\circ} \leq \alpha \leq 20^{\circ}$ | 2.9° |
| (2) Spill prevention in degrees (angle between centerline of test spout in its resting position and the horizontal plane). | 30° (min) | 43.8° (min) |
| (3) Test nozzle penetration of restrictor | 2.25 CM (min) | 4.73 CM |
| (4) Angle $\beta$ in degrees. | none | 1.3° |
| (5) Length 'X' in centimeters | none | 0.77 to 1.27 CM |

| Fill Pipe Specification | ARB Specification | Manufacturer Specification* |
|---|---|---|
| (1) Fill pipe face surface in TIR. | 0.025 CM | 0.025 CM |
| (2) Fill pipe face outside diameter. | 5.75 CM (max) | 5.13 CM (max) |
| (3) Internal locking lip in degrees of the inside circumference | 100°(min) | 128° to 132° |
| (a) degrees extending each side of reference plane. | 35° (min) **LS each side **RS | 63° to 67° (LS); 63° to 67° (RS) |
| (4) Height of lip measured from fill pipe Inside wall; or | 0.25 CM (min) | 0.28 to 0.33 CM |
| height of lip measured from fill pipe outside wall for outside diameters between 5.20 and 5.75 CM. | 0.85 CM (min) | N/A |
| (5) Depth of lip (D) in centimeters | $0.4 \leq D \leq 1.3$ | 0.77 to 1.27 CM. |

| Offset | ARB Specification | Manufacturer Specification* |
|---|---|---|
| Offset A | none | 1.16 |
| Offset B | none | 0.52 |

Statement of Compliance

The above listed vehicle models meet all criteria for compatibility with certified vapor recovery nozzles and hoses as outlined in FAO procedure ESA08P-812.

* Dimensions include adverse tolerance conditions.
** LS = Left side of reference plane.
** RS = Right side of reference plane.

Issue Date: 11/03/2011

## Section 18.00.00.00: Revisions

The 2013 MY Common Section
Initial submission date of 10/5/2011

| Revision Number | Revision Date | Sections(s) Affected | Description of Revision |
|---|---|---|---|
| 1. | 3-9-12 | Index,12.02.02.00,14.01.00, 16.11.03.00,16.13.00.00, 16.13.03.00 | Correct errors and omissions from initial publication. Includes additional details requested by CARB. |
| 2. | 4-4-12 | 16.11.01.00, 16.11.03.00, 16.05.00.EGR 1 | Correct errors and omissions from last revision. Includes additional details requested by CARB. |
| 3. | 7-12-12 | Index<br>09.01.00-03,<br>09.01.02.00,<br>12.01.01.00,<br>12.01.02.00,<br>12.02.01.01,<br>12.02.01.02,<br>12.03.00.00,<br>12.03.01.00,<br>12.03.02.00,<br>15.01.00.00,<br>16.04.00.00,<br>16.05.00.00,<br>16.05.00.01,<br>16.05.00.02,<br>16.05.00.03,<br>16.05.01.01,<br>16.05.01.02,<br>16.06.02.01-14,<br>16.11.01.00,<br>16.11.02.00,<br>16.11.03.00,<br>16.13.00.00,<br>16.13.03.00, | Correct errors and omissions from last revision.<br>Add new or revised information. |
| 4. | 7-23-12 | Index,<br>16.11.01.00; | Correct errors and omissions from last revision.<br>Add new or revised information.<br>Add bookmark labels. |
| 5. | 7-26-12 | 16.13.00.00,<br>16.13.03.00 | Correct errors from last revision. |
| 6. | 12-13-12 | 03.01.00.00,<br>03.02.00.00,<br>12.01.01.00,<br>12.01.02.00,<br>12.03.00.00, | Correct errors and omissions from last revision.<br>Updates for new or revised information.<br>Adds greenhouse gas compliance and attestation information. |

# Section 18.00.00.00: Revisions

The 2013 MY Common Section
Initial submission date of 10/5/2011

| Revision Number | Revision Date | Sections(s) Affected | Description of Revision |
|---|---|---|---|
| | | 12.03.01.00,<br>12.03.02.00,<br>12.04.02.01,<br>12.04.02.06,<br>14.01.xx.xx,<br>14.01.03.01,<br>16.06.02.xx,<br>16.11.01.00,<br>16.13.00.00,<br>16.13.01.01,<br>16.13.01.02,<br>16.13.01.04,<br>16.13.03.00,<br>17.01.00.00,<br>18.00.00.00 | |
| 7. | 4-3-2013 | 04.00.00.01<br>12.04.01.02<br>14.01.01.12<br>16.11.03.00<br>16.13.03.00 | Correct errors and omissions from last revision.<br>Updates for new or revised information. |
| 8. | 12-16-2013 | 09.01.xx.xx<br>12.01.01.00<br>12.04.02.08<br>16.05.00.xx<br>16.06.02.xx<br>16.11.03.00<br>18.00.00.00 | Correct errors and omissions from last revision.<br>Updates for new or revised information.<br>Final update |